

NEW CARBONIFEROUS CRINOIDS FROM EASTERN AUSTRALIA

GARY D. WEBSTER AND PETER A. JELL

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New crinoids are described from the Carboniferous of Queensland and New South Wales. Early Carboniferous faunas are dominated by actinocrinitids and platycrininitids. The geographic distribution of *Aacocrinus*, *Dialutocrinus*, *Sampsonocrinus*, *Litocrinus*, *Prininocrinus* and *Holcocrinus* is extended with the first report of these genera from Australia. A fauna from the Neerkol Formation of Queensland containing acrocrinids, an euspirocrinid and a scytalocrinid is the first Late Carboniferous fauna recognised from the non-equatorial belt or higher latitudes. New genera and species introduced are *Denarioacrocrinus neerkolensis*, *D.? ornatus*, *Neerkolocrinus typus* and *Kopriacrinus mckellari*. New species described are *Aacocrinus acylus*, *Manillacrinus acanthus*, *Sampsonocrinus caumindahensis*, *Prininocrinus namoiensis* and *Holcocrinus barrabaensis*. A neotype is designated for *Synbathocrinus ogivalis*. Australian Early Carboniferous crinoid faunas are most closely allied to North American faunas, but developed geographically widely separated from them. □ *Crinoids, Carboniferous, Queensland, New South Wales.*

Gary D. Webster, Department of Geology, Washington State University, Pullman, Washington 99164-2812, USA; Peter A. Jell, Queensland Museum, P.O. Box 3300, South Brisbane 4101, Australia; 14 June, 1998.

The few Carboniferous crinoids described from Australia have been reported from NSW and Queensland. De Koninck (1878, 1898) reported 5 species from 2 unknown horizons at Burrigood and Glen William, NSW. Etheridge (1892) described 3 camerates from the Mirari Limestone at Greenhills and 1 from Chalky Gully, NSW. This was followed by description of camerates and cladids from the 'Gympie Beds' (incorrectly assigned to the Permian initially), Queensland (Etheridge in Jack & Etheridge, 1892). Identifications were based on the broad concepts of taxa at the time and, with few exceptions, were tentative at best.

More recent reports of crinoids are based on moderately to well-preserved calyces and crowns, allowing more detailed identifications based on modern concepts of taxa. These reports have been an actinocrinitid calyx from Swain's Gully (Pickett, 1960), an acrocrinid from the Late Carboniferous of Queensland (McKellar, 1966), a Visian *Physetocrinus* and two unidentified inadunates from Queensland (Campbell & McKellar, 1969), camerates and inadunates from the Goonoo Goonoo Mudstone and Namoi Formation, NSW (Campbell & Bein, 1971) and a glaphyrocrid and eumorphocrid from the New England Fold Belt (Lindley, 1979, 1988).

Carboniferous crinoid specimens that have remained undescribed in survey, university, museum and private collections have been drawn

together for detailed study. These specimens add significantly to the known diversity and stratigraphic distribution (Table 1) of the Australian faunas. Our purpose is to: 1, describe the available specimens; 2, provide new data or interpretations of some of the earlier described material; and 3, relate all this material to known faunas elsewhere in the world.

FAUNAL ANALYSIS

We recognise 35 Early and 5 Late Carboniferous crinoids (Table 1) in Queensland and NSW. This does not include taxa based on stem segments, disarticulated cup plates and fragmentary specimens described by de Koninck (1878, 1898), Etheridge (1892) and Etheridge (in Jack & Etheridge, 1892). Several of the taxa in these reports are based on more complete specimens; 3 are accepted and the others are reassigned herein.

Early Carboniferous crinoids are recognised from 5 formations in Qld and 4 or 5 formations in NSW. Late Tournaisian faunas from the Namoi Formation, Goonoo Goonoo Mudstone and Dangarfield Formation of NSW and the Malchi Formation of Qld are considered coeval and all contain 1 or 2 species common to 2 of the formations. No species occurs in all 4 formations. Camerate crinoids are the most diverse forms in each of the faunas and the only crinoids known from the Dangarfield Formation. The Malchi

Formation has the most diverse fauna and includes the only Tournaisian flexible crinoids recognised in Australia.

Visean faunas are from 2 or 3 formations in Qld and 1 in New South Wales. Except for *Aacocrinus* in the Tournaisian or Visean Tellebang Limestone and the Caswell Creek Group, these faunas contain no genera in common. The only non-camerate taxon in these faunas is the disparid *Litocrinus* in the Baywulla Formation.

Camerate calyces and tegmens have also been found in reef talus of the type section of the Early Carboniferous Lion Creek Limestone west of Rockhampton. However, they are weathered, or so fragmentary, that it has been impossible to identify them below family level. At least 5 genera are present, based on cup shapes and plate structures. In situ crinoid holdfasts are present in the reef core, from where the calyces are thought to have been derived.

Campbell & Bein (1971) noted that Australian Early Carboniferous crinoids have more affinity with North American faunas than do the co-occurring brachiopods. However, they also noted that when the interior of many of the brachiopods described from North America become known this difference may not be so great. Recognition of a rhodocrinitid, *Aacocrinus*, *Sampsonocrinus*, *Cribanocrinus*, *Dichocrinus*, *Dialutocrinus*, *Litocrinus*, *Priniocrinus* and *Holcocrinus* in the Early Carboniferous and an acrocrinid and scytalocrinid in the Late Carboniferous of Australia strengthens the crinoid affinities with North America and Europe. *Aacocrinus*, *Cribanocrinus* and *Priniocrinus* were restricted to North America and *Dialutocrinus* to Europe (Lane & Sevastopulo, 1987, 1992).

Ranges for Lower Carboniferous crinoid genera were given in Lane & Sevastopulo (1987, 1992), and the differences in the ranges between North America and Europe were noted along with first and last occurrences. They also pointed out that, although some differences in ranges and origins and extinctions were noted, most were relatively minor and perhaps the result of better definition of the North American genera and sampling artifacts. All of the Australian crinoid genera that are known from North America and Europe are of Tournaisian age, although some of the genera range into the Visean or younger in North America or Europe (Lane & Sevastopulo, 1987, 1990). These genera strongly support a late Tournaisian age for the Namoi Formation, Goonoo

Goonoo Mudstone, Dangarfield Formation and the Malchi Formation as had been suggested by other invertebrate fossils (Campbell & Bein, 1971; among others).

Camerate crinoids, that evolved rapidly and that are diverse and most abundant in North America during the middle Tournaisian through Visean, are the Rhodocrinitidae, Actinocrinitidae, Batocrinidae, Coclocrinidae, Dichocrinidae and Platycrinidae (Lane & Sevastopulo, 1987). The Batocrinidae and Coelocrinidae are known only in North America, the others are well represented in equivalent strata in Europe and Russia. Except for the Batocrinidae and Coelocrinidae these families are represented in equivalent strata of eastern Australia, but presently are known from fewer genera than in Europe or North America.

Disparid (Allagecrinidae, Synbathocrinidae) and poteriocrinid (Poteriocrinitidae, Scytalocrinidae, Graphiocrinidae) crinoids are represented in the Early Carboniferous Australian faunas by 1 or 2 genera each. These families are represented in North America and Europe by several genera and underwent rapid diversification during the Early Carboniferous (Lane & Sevastopulo, 1990).

Flexible crinoids are represented by 2 poorly preserved specimens assigned to taxocrinid and sagenocrinid species. Both of these groups are common in the Early Carboniferous of Europe and North America, and they are known in Russian and Chinese faunas (Lane & Sevastopulo, 1990).

Late Carboniferous crinoids in a Westphalian horizon in the Neerkol Formation the Acrocrinidae, Euspirocrinidae and Scytalocrinidae. The Acrocrinidae range from Tournaisian into the Stephanian. Although known from the Early Carboniferous of North America, Europe and Russia, in the Late Carboniferous they are known only from North America where they underwent a rapid diversification (Moore & Strimple, 1969). Euspirocrinids are most common in the Ordovician and Silurian, waning thereafter. They are represented in North America by *Parisocrinus* and *Zygotocrinus* in the Early Carboniferous. The discovery of euspirocrinids in Australia in the Late Carboniferous and Permian (Webster & Jell, this volume) extends their geographic and stratigraphic range. Scytalocrinids are common in Early and Late Carboniferous deposits worldwide.

If all of the reported Early Carboniferous marine fossil occurrences are plotted on biogeographic

reconstructions, such as Bambach (1990), they lie between 45° N and S latitudes, mostly within 30° of the palaeoequator (Campbell & McKellar, 1969). The faunas are equatorial belt organisms and not truly cosmopolitan (Bambach, 1990). On recent plate reconstructions of Early Carboniferous biogeographic regions (Bambach, 1990) Australia is located on the E edge of what was becoming Pangea. Thus, the Australian crinoid faunas evolving in basins along the W border of Panthalassa in the Tournaisian and Viséan were well away from the European and North American faunas on the N and W sides of the continental masses, although still in the equatorial belt. A developing Tethys lay to the N and W of the Australian plate. Migration routes and sites of origin are uncertain for many genera at this time (Lane & Sevastopulo, 1987, 1990).

By Westphalian time the Yarrol Shelf of east-central Queensland was between 55° and 60°S latitude. The crinoid fauna of the Neerkol Formation on the Yarrol shelf is the only higher latitude, cooler water, non-equatorial belt fauna known from the Late Carboniferous. The 2 species of acrocrinids in this fauna show greatest affinity with correlative taxa in the midcontinent of North America described by Moore & Strimple (1969). The euspirocrinids (*Kopriacrinus* gen. nov., *Neerkolocrinus* gen. nov.) are an extension of the family into the Late Carboniferous, and the scytalocrinid (*Prininocrinus*) is an extension of a genus previously known from the Early Carboniferous of NW Canada.

SYSTEMATIC PALAEOONTOLOGY

Crinoid terminology follows Moore & Teichert (1978), with columnal patterns after Webster (1974). Measurements are given as: length, parallel to the central axis; width, transverse to, but never cutting or joining the central axis; and depth or thickness, normal to and may join the central axis. Curvature of the cup walls, plate circlets within the cup and fixed brachials are referred to as: incurved if distally bending toward, vertical if parallel to, weakly to strongly flaring if bending away from and horizontal if perpendicular to the central axis.

Material collected by us came from localities entered in the Queensland Museum Locality Register (QML) and is curated in the Queensland Museum Palaeontological Collection (QMF). Other palaeontological collections referred to are indicated by the following prefixes: Geological Survey of Queensland, Brisbane (GSQ); Geological Survey of New South Wales, Lidcombe

(MM); Australian National University (ANU) and Australian Museum, Sydney (AMS). Localities are in Queensland unless otherwise noted.

Subclass CAMERATA Wachsmuth & Springer, 1885

Order DIPLOBATHRIDA

Moore & Laudon, 1943

Superfamily RHODOCRINITOIDEA

Roemer, 1855

Family RHODOCRINITIDAE Roemer, 1855

Rhodocrinitid gen. nov.

(Fig. 1F)

MATERIAL. QMF38955, QMF38956, locality and horizon unknown, probably Tournaisian Namoi Formation, NSW. Collected by G.M. Philip.

DESCRIPTION. Crown small, 14.3mm long, 5.7mm wide, arms gently splayed. Cup bowl shaped, 5.1mm long, 5.0mm wide, moderately coarse stellate ray ornament, plates moderately inflated. Infrabasals 3?, small, confined to shallow basal cavity. Basals 5?, hexagonal, 1.9mm long, 1.7mm wide, proximally forming base of cup, distally forming base of cup wall, strongly convex transversely and longitudinally. Radials 5?, heptagonal, 1.5mm long, 1.7mm wide, strongly convex transversely and longitudinally. Primibrach 1 hexagonal, 1.1mm long, 1.2mm wide. Primibrach 2 axillary, heptagonal, 1.1mm long, 1.2mm wide. Secundibrach 1 attached to calyx; secundibrach 2 free. All free brachials uniserial, very thick, proximally rectilinear, distally cuneate, narrow, strongly convex transversely, straight longitudinally, with slender pinnule on long side. Secundibrach 4 axillary, no further branching. Arms branching isotomously, 4 in exposed ray, 20 total if all rays branch uniformly. One pinnule per brachial. Pinnulars very slender, elongate, with longitudinal angular ridge, longer than brachials. Interradial series 1-2-2-2-tegmen plates. Tegmen and anals unknown. Stem circular in section, homomorphic, proximal columnal 0.8mm in diameter. Lumens small, circular; crenularium narrow; latus gently convex.

REMARKS. The crown (Fig. 1F) is flattened with one ray central and part of a second ray along the right side of the specimen. The interray is well-developed, narrowing at the distal end but leaving an obvious gap between the rays at the summit of the fixed arms.

The brachials resemble those of a 4-armed dichocrinid or a primitive poteriocrinitid such as *Liparocrinus*. Most rhodocrinitids have biserial

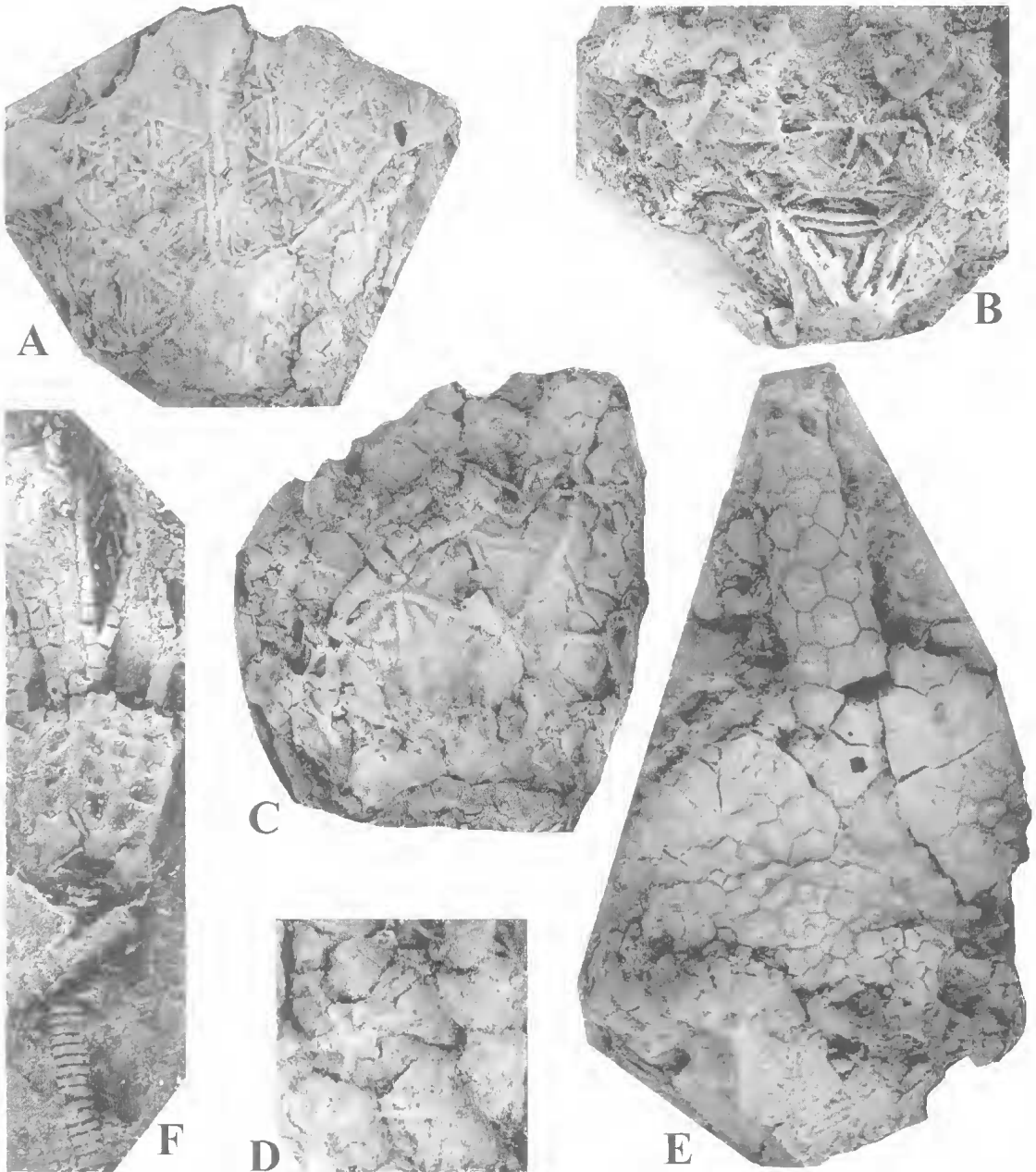


FIG. 1. A-E, *Actinocrinites* sp. 1. A, A ray view of partial calyx QMF38927 $\times 1.6$. B, lateral view of distorted partial calyx QMF38932 $\times 2.5$. C, B ray view of partial calyx QMF38930 $\times 1.6$. D, exterior view of abraded calyx plates QMF38933 $\times 2.2$. E, lateral view of partial theca and tegmen with long anal tube QMF38928 $\times 2.5$. F, *Rhodocrinitid* gen. nov., lateral view of crown QMF38955 $\times 4.8$.

arms or the uniserial brachials, a primitive condition, are very wide.

The stellate ornament, although known in rhodocrinitids, such as *Diamenocrinus* and *Rhodocrinites*, is not common. The arm

branching pattern is slightly advanced as most rhodocrinitids branch on the 2nd secundibrach and then again on the 6th tertibrach or higher and commonly branch one or more times at a higher level. The unfigured specimen (QMF38956) is

crushed, the orientation is uncertain, plate relationships are masked and the ornamentation is only partially preserved.

The specimens may represent a new genus, judged to belong to the rhodocrinitids, but without exposure of the anals, neither specimen is adequate to serve as a holotype. They are associated on a small slab with a scytalocrinid? indeterminate and *Dichoerinus* cf. *D. laudoni*.

Order MONOBATHRIDA

Moore & Laudon, 1943

Superfamily PERIECHOCRINOIDEA Bronn, 1849

Family ACTINOCRINITIDAE Austin & Austin, 1842

REMARKS. Actinocrinitids are among the most common elements in most major Tournaisian or Visean faunas although Visean actocrinitids are relatively rare in Europe. Moore & Laudon (1943) recognised that the actinocrinitids were derived from the periechocrinids and Brower (1967) subdivided them into 4 sections, which were recognised as subfamilies by Ubaghs (in Moore & Teichert, 1978). Brower (1967) also considered the possibility that *Actinocrinites* might be polyphyletic and Campbell & Bein (1971), noting the differences in the arm structure, considered the Eumorphocrininae to be polyphyletic. Webster & Lane (1987) expanded Ubaghs's (in Moore & Teichert, 1978) key to identification of the genera of the Actinocrinitidae to include taxa introduced between 1978 and 1987.

We recognise that the present classification needs revision and does not reflect the phylogeny of a family that is considered polyphyletic. A systematic revision of the Actinocrinitidae would require inclusion of the Periechocrinidae and is beyond the scope of this study. We continue to use the present classification for convenience, noting the general morphologic relationships of the taxa described for future reference.

Identification of genera of the Actinocrinitidae is difficult based on fragmentary thecae or calyces in which the tegmen or distal ends of the protruded arm lobes are absent. Fragmentary material commonly does not provide information about the shape of the calyx which is important in the present classification. The presence or absence of an anal tube is recognised as the major difference between *Aacocrinus* and *Diatorocrinus*. Without the distal ends of the protruded arms, it may be impossible to tell the number of arms per ray, which is the major

difference between *Actinocrinites* and *Aacocrinus*. In some instances the number and type of free arms may be needed, such as *Cytidocrinus* and *Maillacrinus*.

Subfamily ACTINOCRINITINAE Austin & Austin, 1842

Actinocrinites Miller, 1821

TYPE SPECIES. *Actinocrinites triacontadactylus* Miller, 1821 from the Tournaisian Mountain Limestone, England; by subsequent designation of Wachsmuth & Springer, 1881.

REMARKS. *Actinocrinites* is thought to have evolved from a periechocrinid in the Late Devonian or Early Carboniferous (Moore & Laudon, 1943) and was exceedingly abundant in the Tournaisian of North America and Europe declining in the Visean. *Actinocrinites* has also been reported in the Early Carboniferous of Japan (Minato, 1951; Minato et al., 1979), eastern Australia (de Koninck, 1878, 1898; Etheridge, 1892; Pickett, 1960) and northern Africa (Termier & Termier, 1950). Webster & Lane (1987) considered Silurian, Devonian and Permian species (Bassler & Moodey, 1943) to be incorrectly assigned to the genus. They also believed many of the Carboniferous species to be synonyms; there are 61 Carboniferous species currently assigned to the genus (Webster, unpublished data). Ausich & Kammer (1991) placed 4 species in synonymy, while establishing one new species, in a morphometric and qualitative analysis of the late Osagean and Meramecian *Actinocrinites* of the Mississippian stratotype region. Additional studies of this type should help resolve the current taxonomic morass of the genus.

We consider the Australian species of *Actinocrinites* described herein to be new species. They are left in open nomenclature, because some specimens are poorly preserved, unsuitable to serve as holotypes and the taxonomy of *Actinocrinites* must be resolved to allow proper comparisons.

Actinocrinites polydactylus Miller, 1821

Actinocrinites polydactylus de Koninck, 1878: 160, pl. 6, fig. 3. 1898: 122, pl. 6, fig. 3.

REMARKS. De Koninck (1877, 1898) described an internal mould of a compressed calyx from Glen William as *Actinocrinites polydactylus* (sic). The basal view of the specimen has a pentagonal axillary second primibrach; it lacks the tegmen and the ornamentation is unknown. The generic assignment is questionable because the arms are not grouped and protruded as in *Actinocrinites*.

Because the ornament is not preserved, the specific assignment is doubtful. It is possible that the specimen is immature and belongs with *Actinocrinites* indet. described below.

***Actinocrinites* sp. 1**
(Figs 1A-E, 2; Table 1)

MATERIAL. QMF38927-38935 from QML508, late Tournaisian, Malchi Formation. All specimens crushed during burial and plates leached by weathering; description based on latex casts. QMF38927, calyx oriented with basal circle centred; P and A rays show secundibrachs, B ray shows proximal tertibrachs. QMF38928, distal part of theca, tegmen and anal tube. QMF38929-38933, calyces with proximal tertibrachs. QMF38934, partial calyx, base up. QMF38935, partial calyx, on side. GSQF10866 and 13489 from GSQ1, K-21, Viséan?, Caswell Creek Group.

DESCRIPTION. Calyx medium sized; arms grouped; tegmen highly arched with long slender anal tube; all plates below tegmen inflated, with prominent hexagonal stellate ridge ornament. Basal circle large, tripartite, horizontal proximally, widely flaring distally; base with large circular stem facet with narrow crenularium on outer margin; base of stellate ridges at horizontal to widely flaring flexure. Radials 5, hexagonal, large, subequal, moderately flared. Primanal large, in radial circle; distal anals unknown. Primibrachs 2: first primibrach hexagonal, adjoined on each side by 2 interprimibrachs; second primibrach axillary, heptagonal, adjoined laterally by 2 interprimibrachs on each side. Secundibrachs 2-4, normally 2. Tertibrachs biserial and free above 2nd tertibrach. Interbraehial series 1-2-3 or 4-?. Minimum 6 arms per ray, where free. Intersecundibrachs not common, rarely 1 or series 1-1. Tegmen moderately high, many small to intermediate inflated ambulacral and interambulacral plates; ambulacral plates slightly larger and elevated above interambulacral plates, with rounded to irregular central nodes. Anal tube projecting above tegmen, with distal anal opening, slender, of alternating rectangular and larger hexagonal plates in tiers, with hexagonal plates of one tier interlock above and below with rectangular plates of adjacent tiers; considerable variability in plate size, extra plates inserted to compensate.

Stellate ridges 4 (2 on either side of sutures to adjacent basal, inner 2 merging at centre of radial) or 5 (from centre of each basal plate) extend from basal circle to radials and anal, 3 or 4 ridges continue onto primibrachs with ray ridge largest; 3 or 4 subhorizontal ridges from radials to adjacent radials or anal, central ridge largest; 3 subhorizontal cross ridges from 1st primibrach to

TABLE 1. *Actinocrinites* sp. 1 measurements (mm).
* = incomplete or crushed.

	38927	38931	38928
Calyx diameter*	34.5		
Thecal length (estimated)	25.0	38.0	
Basal circle diameter	9.9	11.1*	
Basal circle length	3.6	4.0	
Radial length	6.3	10.8	
Radial width	8.6	11.7	
First primibrach length	5.9	8.5	
First primibrach width	6.6	8.4*	
Second primibrach length	3.3	6.0	
Second primibrach width	5.5	7.7	
First secundibrach length	7.5		
First secundibrach width	6.6		
Stem facet diameter	3.7	3.5	
Tegmen length*			15.5
Anal tube length*			15.8
Anal tube diameter			6.3

1st interprimibrach or 2nd anal, central ridge largest; 3 diagonal ridges from radials to 1st interprimibrach, central ridge largest; subhorizontal and diagonal ridges continue onto 2nd tier of interprimibrachs; lateral ridges merge across plates to form small triangles at apices of plate junctions; triple ridges continue on interprimibrachs to tegmen; single ridge continues on secundibrachs, tertibrachs, and intersecundibrachs; distally ridges grading into discontinuous aligned nodes or decrease in number in some interrays.

Stem circular transversely, heteromorphic; noditaxis N323132313231323. Columnals much shorter than wide; latus convex; lumen large, eircular; artium with narrow crenularium, slightly narrower areola and narrower spatium; nodals may bear short spines between eirral facets.

REMARKS. *Actinocrinites* sp. 1 differs from *A.*? sp. 3 by having more complex stellate ornamentation. The ornament of *A.*? sp. 3 consists of inflated ossicles with apical pits and single stellate ridges that are confined to the impressed ridges, not expressed as ridges across the inflated surface. *Actinocrinites* sp. 2 lacks thecal plate ornament except for impressed sutures and apical pits. The 3 species suggest a progression from unridged to complex stellate ornament. This is not an lineage as *A.* sp. 1 and *A.*? sp. 3 occur together in the Roekhampton Group, whereas *A.* sp. 2 occurs in the younger Caswell Creek Group.

Both single and complex stellate ridge ornaments are developed in *Actinocrinites* and Waehsmuth & Springer (1897) included specimens of both

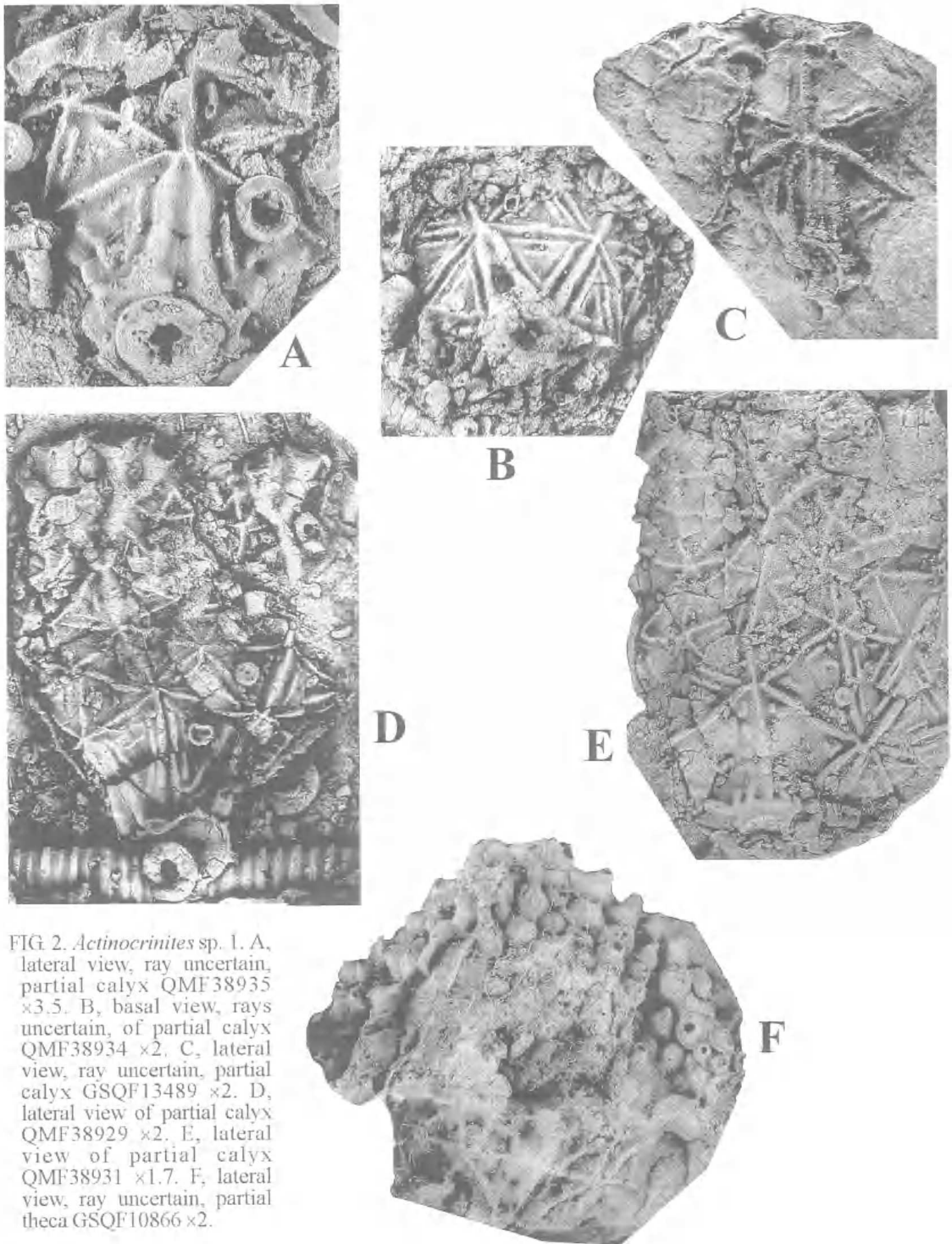


FIG. 2. *Actinocrinites* sp. 1. A, lateral view, ray uncertain, partial calyx QMF38935 $\times 3.5$. B, basal view, rays uncertain, of partial calyx QMF38934 $\times 2$. C, lateral view, ray uncertain, partial calyx GSQF13489 $\times 2$. D, lateral view of partial calyx QMF38929 $\times 2$. E, lateral view of partial calyx QMF38931 $\times 1.7$. F, lateral view, ray uncertain, partial theca GSQF10866 $\times 2$.

types in species such as *A. multiradiatus* (Shumard, 1858) and *A. verrucosus* (Hall, 1858). Single and multiple stellate ridge ornaments are also present in other actinocrinitids and other camerate families. The widespread occurrence and possible repeated development of these features suggest that it is a functional ornament.

Brower (1967) suggested that actinoerinitids may be polyphyletically derived from the periechocrinitids, many of which have the single or multiple stellate ridge ornament. The dimicrocrinitids are periechocrinitoids with infrabasals and should also be considered as possibly ancestral to the actinoerinitids. However, origin of the actinoerinitids is beyond the scope of this study.

A pluricolossal and disarticulated columnar at the base of the calyx on the slab with QMF38929 are included in *A. sp. 1*, as they have the identical articular facet as that of the calyx. A 12.3mm diameter unerusting holdfast with a round articular facet (3.7mm diameter) bearing a central depression and large circular lumen impression is on this same slab and may belong to an immature *Actinocrinites sp. 1*.

This description is based on QMF38927, 38928 and 38931, with variations noted from other specimens.

Actinocrinites sp. 2 (Figs 3, 4D)

MATERIAL. GSQF13490-13494 from GSQL3006, early or middle Tournaisian, Neil's Creek Clastics.

DESCRIPTION. Calyx bowl shaped, 20mm long (estimated), 35mm wide (estimated), sutures impressed; calyx plates inflated, without ribbing; arms grouped, flaring with 1st primibrach; tegmen probably moderately inflated with anal tube. Basals 3, equal, horizontal proximally, flared distally, visible in side view of cup; basal eirelet diameter 8.4mm. Radials 5, heptagonal, large, 6.9mm long, 7.6mm wide, moderately flaring. Primal hexagonal, in radial eirelet; anal series: P-2-3-3 minimum, continuing onto tegmen. First primibrach hexagonal, 5.4mm long, 5.8mm wide, incurved slightly from radials. Axillary 2nd primibrach heptagonal, adjoined laterally by 2 interray plates, outflaring distally. First secundibrach hexagonal, wider than long, strongly outflaring. Axillary 2nd secundibrach pentagonal, wider than long, gently upflaring. Arms free with first or 2nd tertibrach. Four arms

per ray. Interray series: 1-2-3-2-?, extending onto tegmen. Tegmen of many interambulaeral plates, 1.7 long, 1.1 wide to 2 long, 2 wide. Numerous ambulaeral plates increase in size towards anal tube, 0.6 long, 0.6 wide to 1.8 long, 1.7 wide. Anal tube subcentral. Stem impression circular, 4mm diameter.

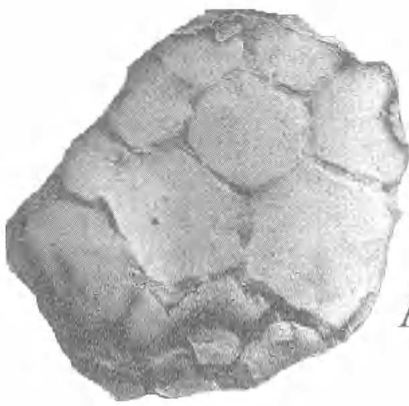
REMARKS. GSQF13490 consists of the internal and partial external moulds of a theca. The internal mould of the calyx is distorted slightly along the D-AB axis, with the tegmen crushed down into the viscerol cavity. Ambulacral trackways are elevated above the interambulacral areas, and the proximal part of the slightly eccentric anal tube projects above the ambulacral areas. The tegmen would have been moderately inflated. The external mould preserves the non-stellate character of the inflated plates of the basal circlet, the B ray and adjacent parts of the interrays on either side. GSQF13493 is the external mould of a calyx crushed along the A-CD axis, retaining the basal eirelet, radials, primibrachs and parts of the interrays; the anal series is lost. GSQF13492 is an internal mould of a part of the tegmen, showing growth lines on some ossicles. The unnumbered specimen is an external impression of a fragment of 2 rays and the interray from the distal ends of the radials through the 1st secundibrachs. It would have been the largest individual of the 5 specimens as a primibrach is 10.3mm long and 10.9mm wide, nearly twice the dimensions of the primibrach of GSQF13490, the most complete specimen. GSQF13491 is a crushed partial theca and GSQF-13494 the external mould of a partial theca.

Actinocrinites? sp. 3 (Fig. 4E,F)

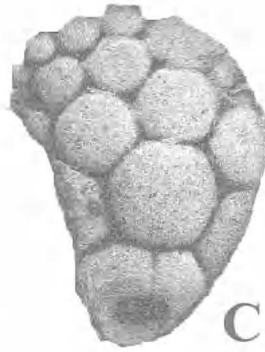
MATERIAL. QMF38936 and 38937, moulds of crushed partial thecae from QML508, late Tournaisian, Malchi Formation.

DESCRIPTION. Calyx high, truncated, conical, arms grouped, plate structure like *Actinocrinites sp. 1*, lacking interscundibrach plates; interprimibrach series 1-2-3-?. Anal series and tegmen unknown. Minimum 4 arms per ray, inner facet on axillary secundibrach wider than outer. Stem facet circular; lumen circular; articulum narrow, arcola more than twice width of articulum, spatium intermediate width.

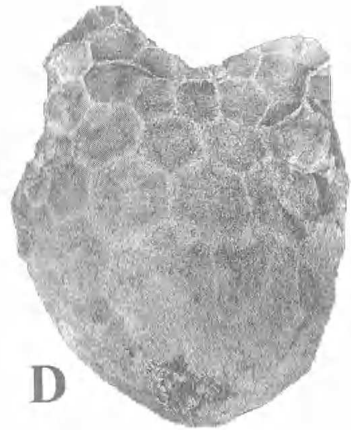
FIG. 3. *Actinocrinites sp. 2*. A,B, B ray and D-E interray views of partial calyx GSQF13493. C-E, B ray, internal A-B interray and oblique internal tegmen views of GSQF13490. F, lateral view of partial tegmen GSQF13492. G, interray view of partial calyx GSQF13494. All $\times 2$.



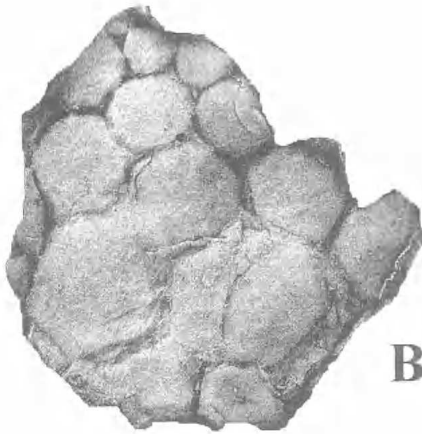
A



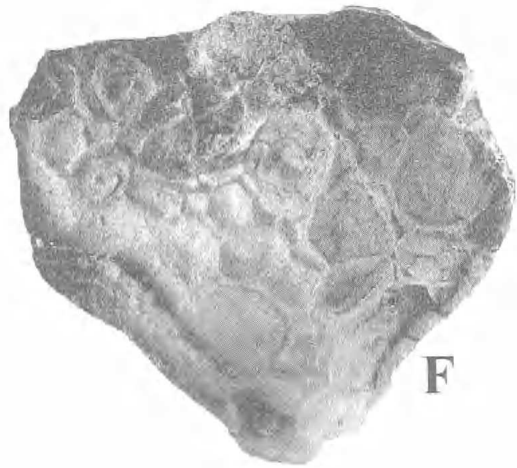
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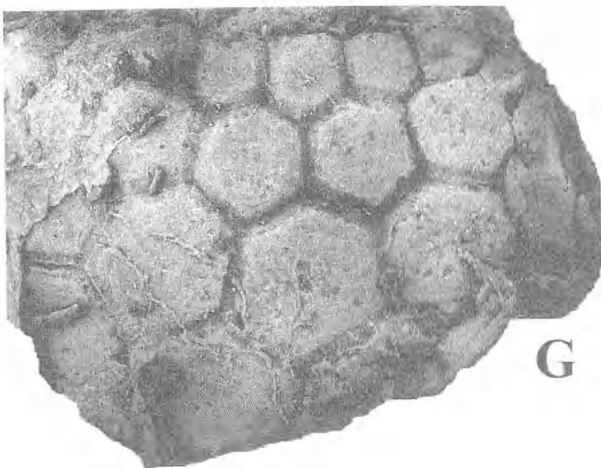
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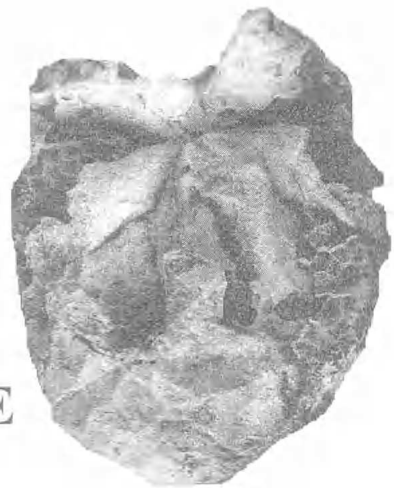
B



F



G



E

QMF38936: Calyx 25.5mm long (estimated); basals 5.2mm long (estimated); radials 6.8mm long, 7.4mm wide; 1st primibrach 5.1mm long, 6.0mm wide; 2nd primibrach 4.6mm long, 5.5mm wide. QMF38937: Basal circlet diameter 11.8mm; basals 4.4mm long; radials 8.0mm long, 10.0mm wide; stem facet 4.5mm in diameter.

REMARKS. The lack of stellate ridge ornament across the inflated calyx plates of *Actinocrinites?* sp. 3 is not an artifact of weathering or abrasion, because the stem facets of the basal circlet and broken proximal columnal of QMF38937 show sharp detail of the culmina and crenellae of the articulum and surfaces of the areola and spatium. The generic assignment is questioned because the tegmen is unknown.

Aacocrinus Bowsher, 1955

TYPE SPECIES. *Aacocrinus nododorsatus* Bowsher, 1955 from the Kinderhookian (Tournaisian) Chouteau Limestone of Missouri; by original designation.

Aacocrinus acylus sp. nov. (Fig. 4A-C)

ETYMOLOGY. Latin, *acylus*, acorn of the holm-oak; refers to the acorn shape of the calyx.

MATERIAL. HOLOTYPE: QMF38953. PARATYPE: QMF38954, external moulds of calyces from QML1248, Tournaisian or possibly Viséan Tellebang Limestone.

DIAGNOSIS. Calyx small, equidimensional; calyx bowl shaped, with single stellate ridge ornament; arms grouped, protruded, flare with axillary 2nd primibrach; tegmen strongly arched, as long as calyx; slightly eccentric anal tube; arms free with tertibrachs, 4 arms per ray; stem facet circular.

DESCRIPTION. Calyx small, equidimensional. Calyx bowl shaped; coarse, single-ridge stellate ornament. Basal circlet large, short, proximally horizontal; large impressed circular stem facet, distally upflared, forming base of walls, visible in lateral view. Radials moderately large, strongly convex longitudinally, moderately convex transversely, forming majority of cup wall. Primanal large, in radial circlet, series unknown; 1st primibrach and 1st interprimibrach subvertical, forming distal part of cup wall. Axillary 2nd primibrach widely flared, lacking stellate ridge ornament; 2nd secundibrach axillary; 4 arms per ray; arms free with

tertibrachs. Tegmen strongly arched, as long as calyx, formed of orals, three series of ambulacrals and interambulacrals; all plates nodose, commonly with large blunt nodes. Anal tube narrow, slightly eccentric, formed of medium-sized strongly nodose to blunt spined plates. Free arms and stem unknown.

REMARKS. Silicification of the siltstone to fine grained sandstone external moulds of *Aacocrinus acylus* obliterated cup plate sutures except those of the basal circlet. Sutures of the brachials commencing with the 2nd primibrach and tegmen plates are well preserved. The stellate ridge ornament is rounded, vague, but obvious. QMF38953 is slightly crushed from compaction and oriented on its side, whereas QMF38954 does not appear to be crushed and is oriented obliquely on its side with nearly all of the tegmen covered. Neither specimen shows the anal series. The generic assignment is based on the plate arrangement and shape of the calyx.

Aacocrinus acylus belongs to the 20-armed group of the genus and has a bowl-shaped calyx, whereas all other species of the genus have a more conical shape. The tegmen has third-order ambulacrals that Brower (1967) noted as the difference between 10- and 20-armed species. Both *A. tetradactylus* Brower, 1967 and *A. chouteauensis* (Miller, 1892), the other 20-armed species, have longer thecae, shorter tegmens and strongly eccentric anal openings.

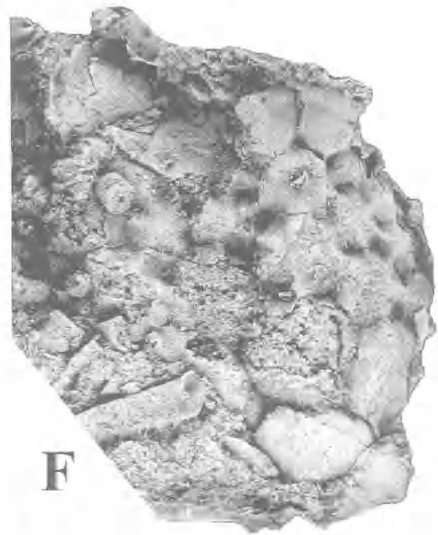
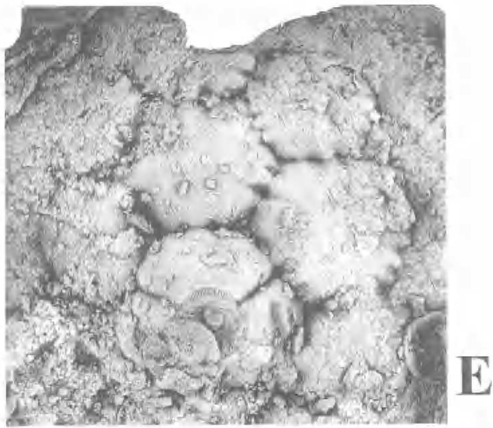
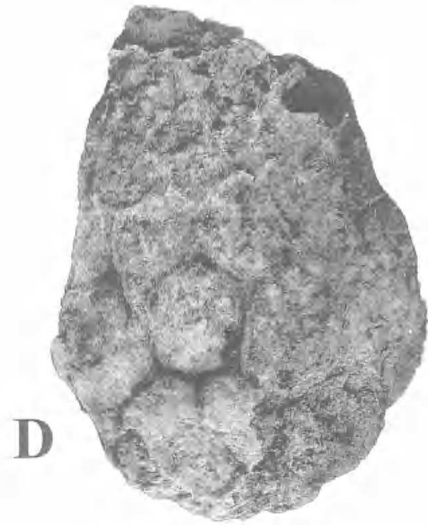
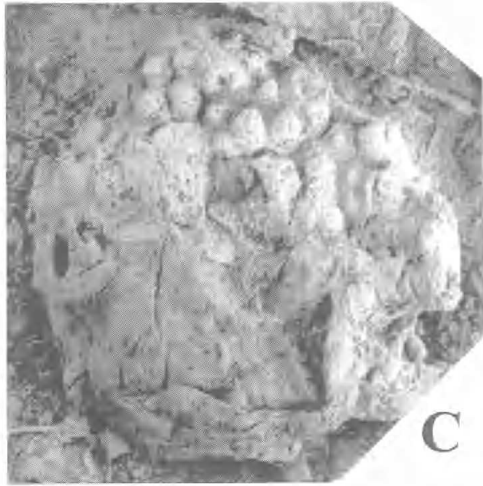
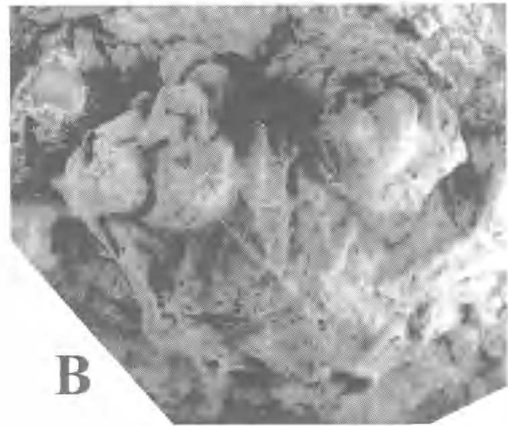
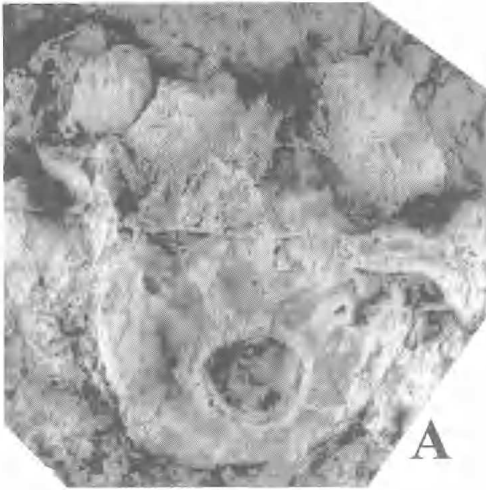
Aacocrinus acylus is the first report of the genus outside the United States. Brower (1967) noted that all identified species are from the Kinderhookian of the midcontinent of the United States, but he also recognised an unnamed Osagean form from the same area. Webster & Lane (1987) reported an early Osagean specimen from the Anchor Limestone of southern Nevada.

Aacocrinus sp. 1 (Figs 5A-G, 6B-H)

MATERIAL. QMF38938-38944, latex moulds of crushed partial thecae from QML508, late Tournaisian, Malehi Formation. GSQF10865, 10867, 10868 and 10871a and b, from GSQL K-21, Viséan? Caswell Creek Group.

DESCRIPTION. Calyx medium sized; arms grouped; tegmen highly arched with one row of plates forming anal tube; all plates below tegmen inflated with prominent hexagonal single ridge

FIG. 4. A-C, *Aacocrinus acylus* sp. nov. A, B, basal and lateral views of paratype, QMF38954 $\times 2.6$. C, lateral view of holotype theca, QMF38953 $\times 2.6$. D, *Actinocrinites* sp. 2, posterior interray view of GSQF13491 $\times 1.6$. E, F, *Actinocrinites?* sp. 3. E, basal view of partial calyx QMF38936 $\times 2$. F, lateral view of partial theca QMF38937 $\times 2$.



stellate ornament. Basal circle large, tripartite, horizontal proximally, upflared distally; base with large circular stem facet with narrow crenularium on outer margin; fluting at base stellate ridges at horizontal to upflared flexure. Radials 5, hexagonal, large, subequal dimensions variable, upflared. Primanal large, in radial circle; distal anals unknown. Primibrachs 2; 1st primibrach hexagonal, adjoined on each side by 2 interprimibrachs; 2nd primibrach axillary, heptagonal, adjoined laterally by 2 interprimibrachs on each side. Secundibrachs 2. Tertibrachs becoming biserial and free after 2nd tertibrach. Interbrachial series 1-2-3-4-tegmen. Tegmen high, formed of many small to intermediate sized inflated ambulacral and interambulacral plates; ambulacral plates slightly larger and with circular to irregular central nodes, elevated above interambulacral plates. Anal opening projecting above tegmen with single row of plates.

Stellate ornamentation of elevated sharp ridges; double and single ridge from basals onto radials and primanal, single ridges on all calyx plates thereafter; double ridge along basal sutures merging at centre of radials to continue as ray ridge; ray ridges largest, subhorizontal and diagonal ridges smaller. Occasional additional accessory node or very short ridge on radials or 1st interprimibrach. Minimum 4 arms per ray, inner facet on axillary secundibrach wider than outer. Stem facet large, circular; lumen large, circular to subpentagonal; articulum narrow, areola more than twice width of articulum, spatium intermediate width.

QMF38938: Calyx 26mm long (est.); basal circle diameter 10mm, 5.3mm long; radials 7.6mm long, 8.3mm wide; 1st primibrach 6.4mm long, 6.4mm wide; 2nd primibrach 5.7mm long, 6.7mm wide; proximal columnal 5.2mm in diameter.

REMARKS. This description is based on QMF-38938, 38941 and 38942 and GSQF10867. Other specimens are included in this taxon because they have the same type of plate ornament. The single stellate ridge ornament results in a less intricate ridge pattern on the calyx. The wider facets on the inner axillary secundibrachs suggest additional branching of the arms, which would result in 6

arms per ray. Known species of *Aacocrinus* have 2 - 4 arms per ray, whereas most species of *Actinocrinites* have 6 arms per ray and an anal tube of variable length.

Aacocrinus sp. 1 differs from *A. acylus* by having a longer, more conical cup and calyx, and a longer tegmen. The tegmen is formed of more numerous plates than any of the American species of the genus and is more similar to that of *Actinocrinites*. *Aacocrinus* sp. 1 is considered a new species but all specimens are incomplete and unsuitable to serve as a holotype.

Manillacrinus Campbell & Bein, 1971

TYPE SPECIES. *Cactocrinus? brownei* Dun & Benson, 1920 from the Namoi Formation, NSW; by original designation.

REMARKS. *Manillacrinus* was incorrectly included in the Eumorphocrinitinae by Ubahgs (in Moore & Teichert, 1978) and Webster & Lane (1987) as they did not recognise the arm grouping of *M. brownei* (Campbell & Bein, 1971, pl. 50, figs 1, 2, 6, 7) and no mention was made in the original descriptions about the arms grouped and protruded, a character of the Actinocrinitinae. *Manillacrinus* is distinguished from other genera of the Actinocrinitinae by the biserial ramules given off the outer sides of the 2 uniserial arm trunks of each ray.

Manillacrinus brownei (Dun & Benson, 1920) (Figs 5H, 6A)

Cactocrinus? brownei Dun & Benson, 1920: 342, pl. 19, fig. 1.
Manillacrinus brownei (Dun & Benson); Campbell & Bein, 1971: 427, pl. 50, figs 1-7; text-fig. 7.

MATERIAL. QMF38945, an external mould of a partial theca, from QML508, late Tournaisian, Malchi Formation. GSQF13495 from GSQF3012, late Tournaisian Malchi Formation, external mould of partial theca.

REMARKS. *Manillacrinus brownei* has protruded grouped arms; sharply elevated, centrally inflated, single ridge, stellate ornament; and 2 ramule-bearing arms per ray. The 2 ramule-bearing arms, combined with the protruded grouped arms, are the most diagnostic characters of the genus. The single ridge stellate ornament of *M. brownei* is not unique to the genus, but the stellate intersecundibrach plate is not common in actinocrinitids. Also, the stellate ridges continue

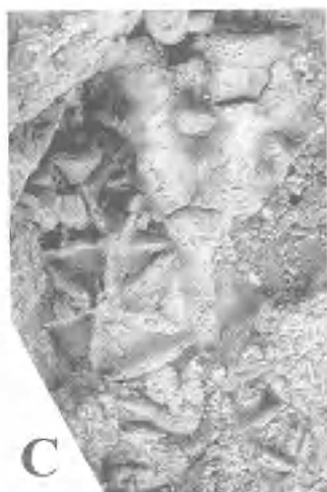
FIG. 5. A-G. *Aacocrinus* sp. 1. A, lateral view of partial calyx QMF38939 $\times 1.7$. B, lateral view of partial calyx QMF38938 $\times 1.6$. C, lateral view of partial calyx QMF38943 $\times 4$. D, interray view of partly disarticulated calyx QMF38942 $\times 2.6$. E, view of crushed theca QMF38944 $\times 2.6$. F, view of basal circle and stem facet QMF38941 $\times 4.2$. G, basal view of partial calyx QMF38940 $\times 3.6$. H, *Manillacrinus brownei* (Dun & Benson, 1920), basal view of partial calyx GSQF13495 $\times 2$.



A



B



C



D



E



F



H



G

without significant decrease in development to the base of the tegmen. The partial calyx GSQF13495 is a basal circle with one ray to the secundibrachs and proximal parts of 2 other rays. It is assigned to *M. browni* because the stellate ornament is so sharp and the ridges are centrally inflated and highly elevated. It also has the double ridges from the basal circle to 2 of the radials. The 2nd specimen QMF38945 is the distal part of a calyx with the stellate ridged intersecundibrach in both rays.

***Manillacrinus acanthus* sp. nov.**
(Figs 7, 8)

ETYMOLOGY. Greek *acanthos*, spine; referring to the short thorns on some of the ambulacral plates of the tegmen.

MATERIAL. HOLOTYPE: MMF33605. PARATYPES: MMF33431 and 33606; other specimens MMF33435 and AMSF65556, all from the late Tourmaisian Nainoi Formation, near Barraba, NSW.

DIAGNOSIS. Ambulacral plates with 1 or 2 short blunt spines midway between free arms and anal tube; calyx high conical.

DESCRIPTION. Calyx 62.3mm long; 30.2-50.6mm wide, (40.4mm average), widest at base; tegmen high, conical; plates tumid; apical pits on calyx; multiple stellate ridge ornament to base tegmen; arms grouped, distinctively protruded; tegmen high arched; short central anal tube. Basal circle tripartite, 9mm long, 12.7mm wide (average), proximally concave, with circular stem facet, distally strongly upflared. Radials 5, septagonal, 12.5mm long, 11.3mm wide, concave to convex longitudinally, moderately convex transversely. Primal anal 10.1mm long, 8.6mm wide, gently convex longitudinally, moderately convex transversely, in radial circle; anal series P-2-3-4-4-tegmen. First primibrach hexagonal, 7.9mm long, 9.0mm wide, moderately convex longitudinally and transversely, adjoined laterally by 2 iBrr on each side. Axillary 2nd primibrach septagonal, 5.1mm long, 8.2mm wide, straight to slightly concave longitudinally, moderately convex transversely, adjoined on outer side by 2 interprimibrachs. First secundibrach pentagonal, 3.4mm long, 4.8mm wide, longitudinally concave, moderately flaring outward, convex transversely. Axillary 2nd

secundibrach pentagonal, 2.5mm long, 5.3mm wide, straight to gently convex longitudinally, convex transversely, widely flaring outward. First and 2nd tertibrachs fixed in calyx, arms free thereafter. Interprimibrach series 1-2-3-2-tegmen; plates convex longitudinally and transversely, decreasing in size distally, last row incurved. Single intersecundibrach octagonal, elongate, with short proximal and distal facets. Multiple stellate ridge ornament of 4-5 ridges from basals to radials, decreasing to single ridge thereafter, continuing to secundibrachs in rays and to tegmen on interbrachs. Tegmen plates large, tumid. Ambulacral plates elevated above interambulacrals, 1 or 2 midway between free arms and anal tube bearing short blunt spines. Anal tube subcentral, formed of 2 rows of polygonal plates. Stem circular; proximal facet 9.5mm diameter (average), with narrow crenularium. Free arms unknown.

REMARKS. *Manillacrinus acanthus* is distinguished from *M. browni* by the spines on the tegmen and the much more conical theca. The adult specimen is much larger than adult *M. browni*.

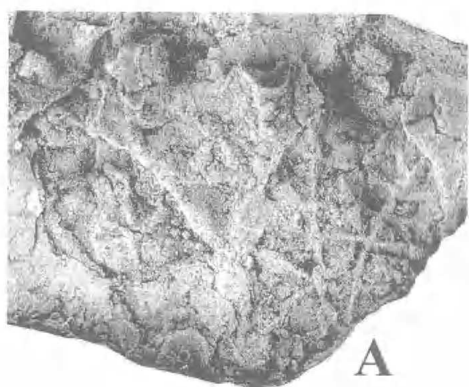
Measurements were taken on the holotype, which is crushed normal to the BC-D plane. Paratype MMF33431 lacks the tegmen. Paratype MMF33606 lacks the basal circle and the tegmen is crushed into the visceral cavity, but the spines on the ambulacral plates are well-preserved. The stellate ridge ornament is poorly preserved on the types but is recognised best on paratype MMF33431. MMF33435 is abnormal with both the A and B radials followed by 4 primibrachs. The distal parts of the calyx are missing and the distal relationship of the ray and interray plates is unknown. AMSF65556 lacks the basal circle, but the two radials and next distal plates have well-preserved stellate ridge ornament.

***Sampsonocrinus* Miller & Gurley, 1895**

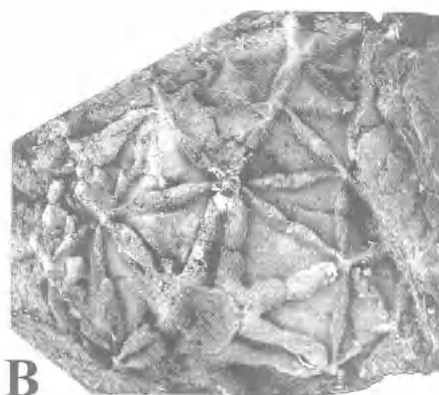
TYPE SPECIES. *Sampsonocrinus hemisphericus* Miller & Gurley, 1895 from the Chouteau Limestone, Missouri; by original designation.

REMARKS. *Sampsonocrinus* is distinguished from *Actinocrinites* by having a lower, more bowl-shaped cup, relatively larger basals and radials and only 4 arms per ray. *Sampsonocrinus* is a

FIG. 6. A, *Manillacrinus browni* (Dun & Benson, 1920), lateral view of partial calyx QMF38945 $\times 1.8$. B-H, *Aacocrinus* sp. 1. B, lateral view of base of partial calyx GSQF10871b $\times 2$. C-G, B ray, oral, posterior views of tegmen, interior B ray and summit oblique of interior of tegmen of GSQF10867 $\times 2$. H, lateral view of partial theca GSQF10868 $\times 2$.



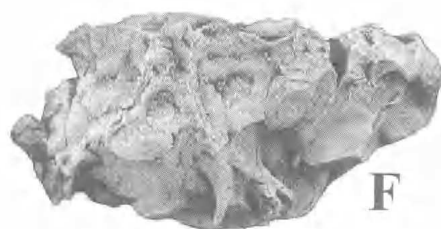
A



B



C



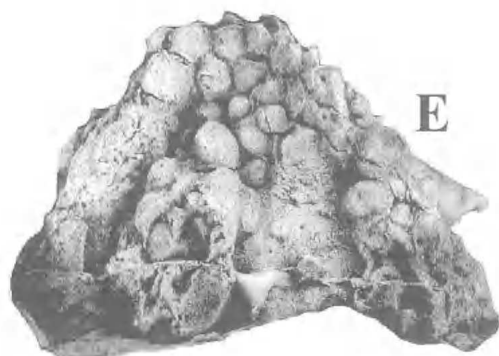
F



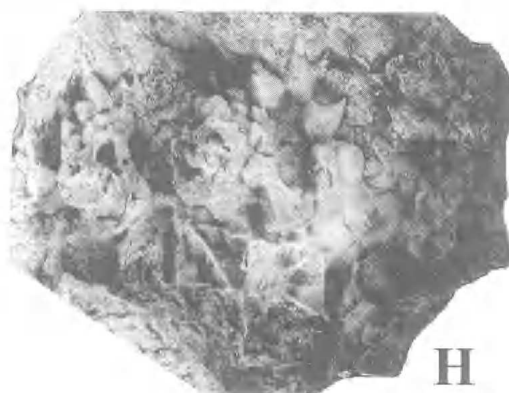
D



G



E



H

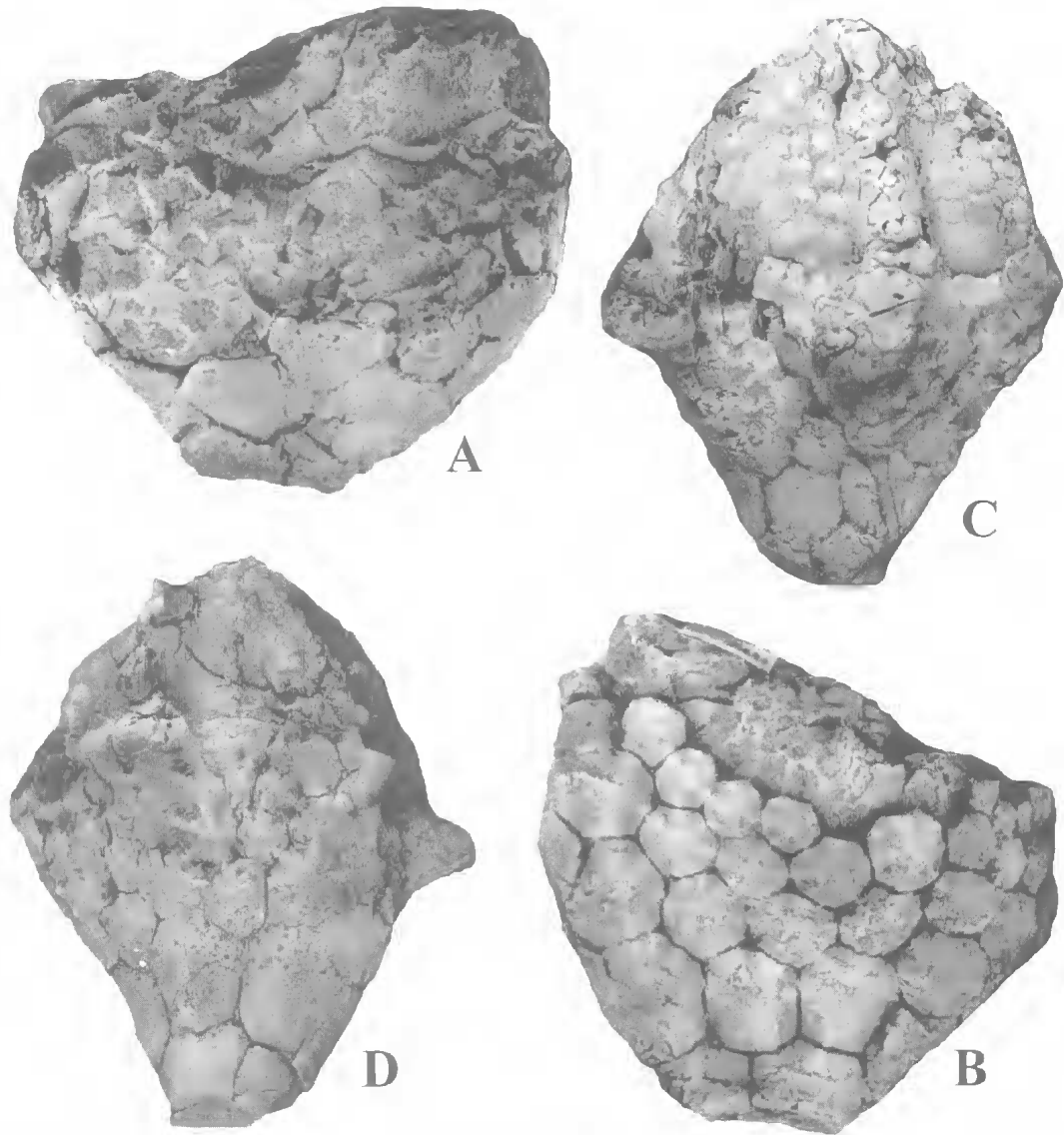


FIG. 7. *Manillaocrinus acanthus* sp. nov. A,B, A-E intertray and posterior views of paratype MMF33431, lacking tegmen $\times 1.7$. C,D, C ray and A ray views of holotype MMF33605 $\times 1.2$.

Tournaisian genus, previously reported from the United States. United Kingdom records are now excluded from the genus (George Sevastopulo pers. comm.) This is the first report of the genus in Australia.

***Sampsonocrinus cannindahensis* sp. nov.**
(Fig. 9)

ETYMOLOGY. From Old Cannindah.

MATERIAL. HOLOTYPE: GSQF10864, external and internal mould of calyx from GSQL K-21, Viséan?

Caswell Creek Group. PARATYPE: QMF17784, internal mould of cup. Collected by C. W. De Vis (no. 649).

DIAGNOSIS. Cup low, broad, with blunt spines or coarse nodes on each of the tegmen plates.

DESCRIPTION. Calyx low bowl-shaped, 19.6mm long (incomplete), 39.8mm wide; plates inflated, bulbous; sharp simple stellate ridge ornament continuous across sutures on all adjacent plates below tegmen; tegmen moderately inflated; arms grouped, projecting subhorizontally. Basal circlelet 4.0mm long (estimated), 8.2mm diameter

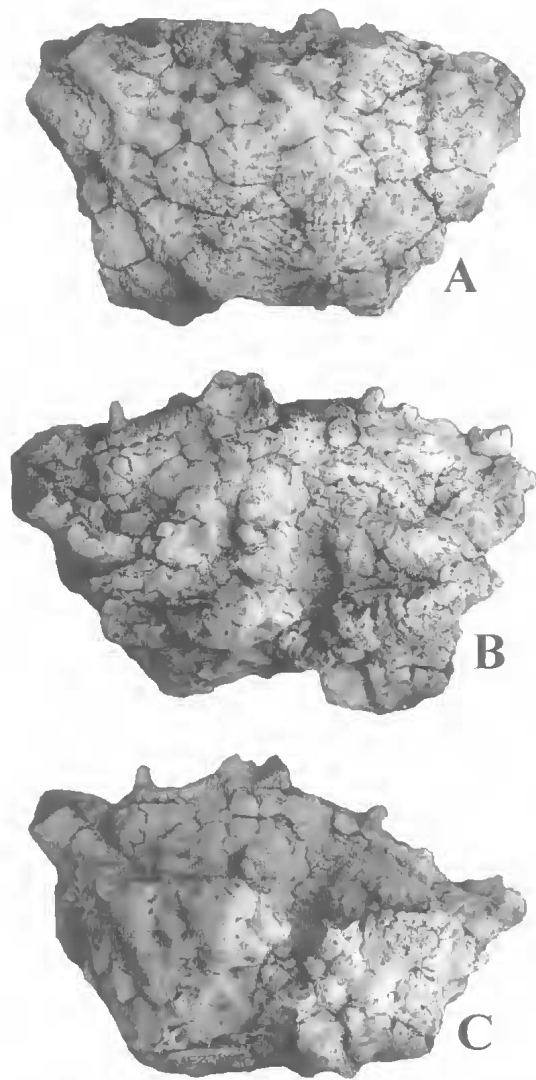


FIG. 8. *Manillaocrinus acanthus* sp. nov., A-C, A ray $\times 1.2$, oblique oral $\times 1.5$ and posterior $\times 1.5$ views of paratype MMF33606, lacking basal circlelet and tegmen crushed into the visceral cavity.

(internally). Radials 5, hexagonal, 4.8mm long (internal), 7.3mm wide (internal), gently convex longitudinally and transversely, widely outflared. Primanal heptagonal, large, in line with radials; anal series P-2-3-3-2-tegmen, wide. First interradiar hexagonal, 5.7mm wide; series 1-2-3-2-tegmen. First primibrach pentagonal, 4.1mm long, 5.4mm wide. C ray 2nd primibrach axillary, pentagonal, 3.0mm long, 3.6mm wide, with distal tip curving outward toward subhorizontal. Single secundibrach axillary, slightly upflared. Arms free with 2nd tertibrach, 4 arms

per ray, 20 arms if branching uniform. Tegmen plates relatively small, strongly inflated into short blunt spines. Orals 5, off centre toward anal interray, larger than other tegmen plates, surrounding anal opening at tegmen apex. No anal tube. Ambulacral plates inflated more than interambulacral with short blunt spines. Stem and free arms unknown.

REMARKS. The holotype internal mould is slightly distorted along the D-AB axis; weathering destroyed most of the external mould of the cup. Ambulacral grooves were elevated above the interambulacral areas, distally merging with them toward the centre of the tegmen, and the eccentric anal tube projected above the tegmen surface. The short calyx of the paratype is crushed inward concentrically around the basal circlelet and the tegmen is not exposed.

Dialutocrinus Wright, 1955

TYPE SPECIES. *Dialutocrinus milleri* Wright, 1955 from the Tournaisian of England; by original designation.

Dialutocrinus? sp. (Fig. 10A-C)

MATERIAL. QMF33864, a partial calyx, from the Viséan? Caswell Creek Group, 7.1 km NE of Monto, on hill on side of road, 24°51'6"S, 151°9'54"E. Collected by Paul Tierney.

DESCRIPTION. Calyx 19.1mm long, 36.3mm wide, conical, with concave sides, with single ridge stellate ornament. Arms very weakly grouped, slightly protruded. Basal circlelet 2.5mm long, 11.1mm wide, flat proximally, widely flaring distally, circular stem impression in basal impression. Radials 5, 7.2mm long and wide, heptagonal, moderately bulbous. Primanal smaller than radials, 6.5mm long, 5.5mm wide, moderately bulbous. Anal series P:2:3:4:?, connected with tegmen. First primibrach hexagonal, 3.9mm long, 6.0mm wide, bulbous, slightly concave longitudinally. Axillary 2nd primibrach heptagonal, 3.8mm long, 6.2mm wide, slightly convex longitudinally and transversely. Interprimibrach series 1:2:3:4:3:?, plates decrease in size distally, forming moderately wide gap between arms at rim of calyx. First secundibrach hexagonal, 3.1mm long, 4.7mm wide, weakly flaring. Axillary 2nd secundibrach pentagonal, 2.8mm long, 4.4mm wide, weakly flaring. Intersecundibrach series 1:1. Minimum 2 tertibrachs. Arms not free until 3rd tertibrach or 1st quartibrach. Probably 8 arms per ray. Stem circular transversely, 4.3mm diameter proximally.

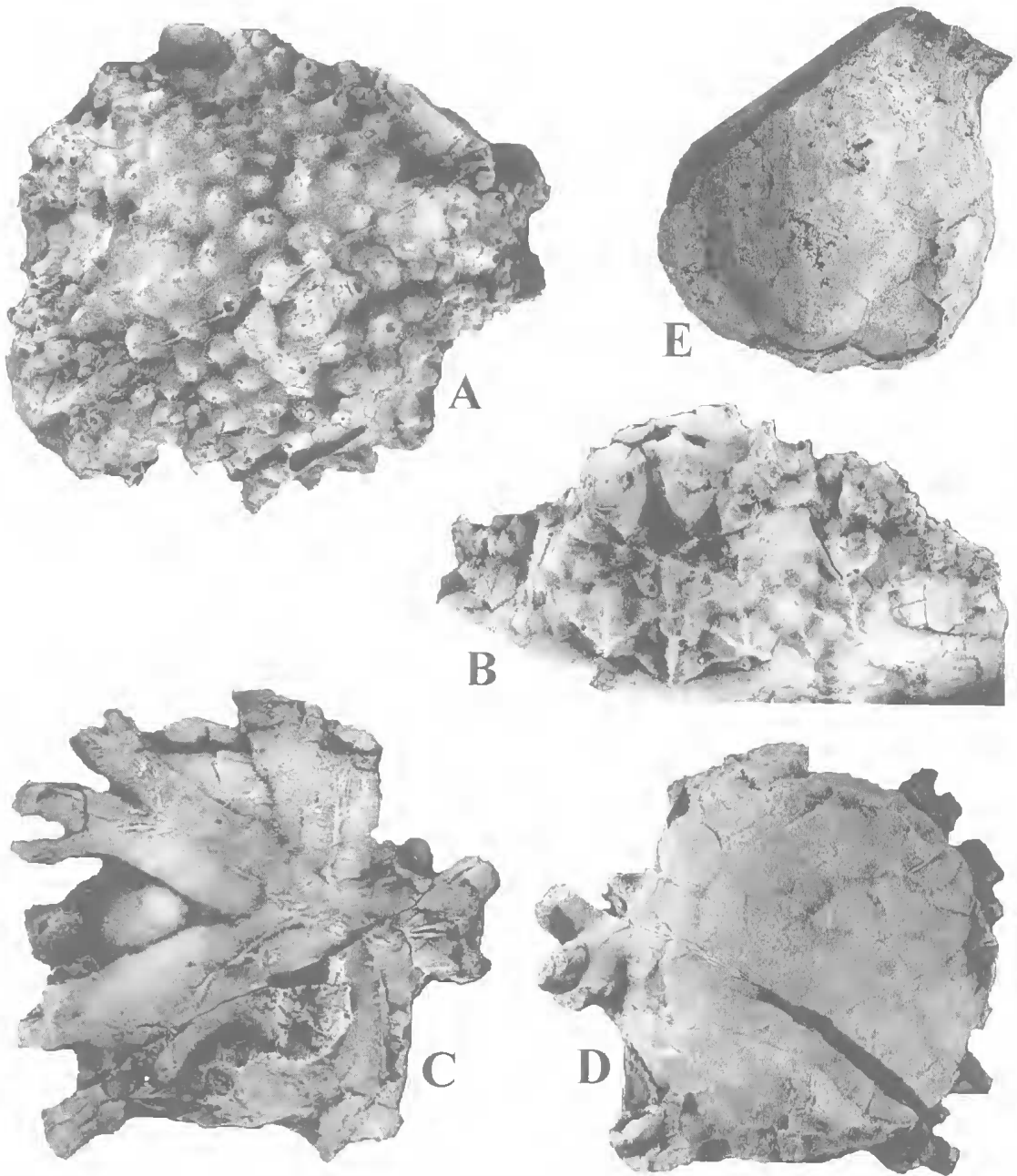


FIG 9. *Sampsonocrinus camindahensis* sp. nov., A-D, external oral and E, ray views and oral and basal views of internal mould of holotype, GSQF10864 $\times 2$. E, B-C interray view of internal mould of paratype, QMF17784 $\times 1.6$.

REMARKS. The specimen lacks the teginen and free arms, and has been slightly distorted by compaction of the eup into the fixed brachials. Plates are re-crystallised and the stellate ornament is nearly lost except on the lower 2 rows of plates

in the DE interray and adjacent parts of the D and E rays. The specimen is questionably assigned to *Dialutocrinus* because it has 2 secundibrachs and the free arms are unknown. The type species, *D. milleri* Wright, 1955, has a single secundibrach

and the inner arm branches repeatedly above the axillary secundibrach; the outer arm remains unbranched. The wide interprimibrach series (1-2-3-4-3-?), single intersecundibrach, calyx shape, cup plate structure, and ornamentation of *D.?* sp. agrees with *D. milleri*. The specimen may represent a geographical variant.

Actinocrinitid indet.
(Fig. 10D,E)

Actinocrinitis sp. ind. Etheridge, 1892: 77, pl. 20, figs 6, 7.
Periechocrinitis indicator Etheridge, 1892: 78, pl. 22, fig. 4.
Periechocrinitis? sp. ind. Etheridge, 1892: 79, text-fig. 1.

MATERIAL. AMSF27094 and 28389 (part and counterpart), locality uncertain within the Clarence town area, UQF13204, from the Tournaisian Wootton Beds, 3.25 miles N of Clarence town, on Glen William Rd, NSW.

DESCRIPTION. Calyx 65.5mm long, 56mm wide (incomplete, crushed). Basal circle tripartite, 23.3mm diameter (minimal), widely flaring. Radials large, 21.3mm long, 21.0mm wide, hexagonal, gently convex longitudinally and transversely, upflared. First primibrach hexagonal, 16.8mm long, 17.4mm wide, gently convex longitudinally and transversely, upflared. Axillary 2nd primibrach pentagonal, 12.7mm long, 15.5mm wide (estimated), concave longitudinally and transversely. Second secundibrach hexagonal, 5.6mm long, 10.2mm wide. Interprimibrach series 1-2-3-?. Anal series, tegmen and stem unknown.

REMARKS. Both specimens are crushed thecae. Measurements were made on AMSF28389. The plates show 9 major growth rings and are preserved as very thin interior rinds. Edges of the plates are preserved as elevated walls marking the sutures. No ornamentation is preserved as the exteriors were lost by weathering. Plates of UQF13204, are weathered and leached, with the remaining calcite very soft and chalky, showing 8 major growth rings.

Provenance of the calyx is given as Clarence town, NSW. There are numerous lenses of limestone within the Wootton Beds between Clarence town and Dungog (Lishmund et al., 1985). Both specimens probably derive from this area.

Actinocrinitis sp. ind. of Etheridge (1892) is probably from the same locality as the described material, or the same horizon from a nearby locality; preservation is similar. Etheridge (1892) reported specimens from the Carboniferous Mirari Limestone, at Greenhills, Paterson to Dungog Road.

Periechocrinitis indicator, from Carboniferous deposits at Chalky Gully, and *Periechocrinitis?* sp. ind., from the Carboniferous Mirari

Limestone at Greenhills, described by Etheridge (1892, p. 69-71, pl. 22, fig. 4; text-fig. 1) may also be conspecific with the material described. Neither of the *Periechocrinitis* specimens are quite as large, but they have similar plate structure. Also, the former is preserved in the same manner as AMSF28389. If all of these specimens are conspecific, the specific name *indicator* will have priority if a genus is specified.

Family DICHOCHRINIDAE S. A. Miller, 1889
Subfamily DICHOCHRININAE S.A. Miller, 1889

Dichocrinus Münster, 1839

TYPE SPECIES. *Dichocrinus radiatus* Münster, 1839 from the Early Carboniferous of Germany; by monotypy.

Dichocrinus cf. *D. laudoni* Broadhead, 1981
(Fig. 11)

MATERIAL. QMF38957, locality and horizon in NSW unknown, probably late Tournaisian Namoi Formation. Collected by L. M. Philp.

DESCRIPTION. Crown small, 12.6mm long (incomplete), 6.0mm wide, expanding gently upward. Cup steeply conical, 7.2mm long, 5.1mm wide, smooth, unornamented. Basal circle bipartite, steeply upflared, visible in side view, 4.2mm long, 2.6mm wide. Radials 5, longer (4.2mm) than wide (2.6mm), expanded gently distally. Radial facet angustary, projecting slightly above shoulders of radial. Anal not exposed. Brachials strongly convex transversely, straight longitudinally, rectilinear. Second primibrach axillary, isotomous branching, no distal branching on preserved secundibrachs; 10 uniserial arms if branching same in all rays. Stem heteromorphic proximally (noditaxis pattern N1), homeomorphic distally. Columnals circular transversely, diameter 1.5mm proximally; latus gently to moderately convex.

REMARKS. This small crown is flattened in the anterior-posterior plane of symmetry. Brachials at the base of the arms are slightly disarticulated from the radials. The conical cup with the basals making up half the cup wall, 10 arms and uniserial proximal brachials are all primitive features in *Dichocrinus*. The specimen is similar to *D. laudoni*, but the stem does not taper away from the cup as it does on the holotype of *D. laudoni* (Broadhead, 1981, pl. 2, fig. 8). Taper of the stem may be a variable feature as the paratype (Broadhead, 1981, pl. 2, fig. 6) and other specimens (Webster, 1997, pl. 2, figs 5, 10) do not show as strong a taper. Distally, the brachials of

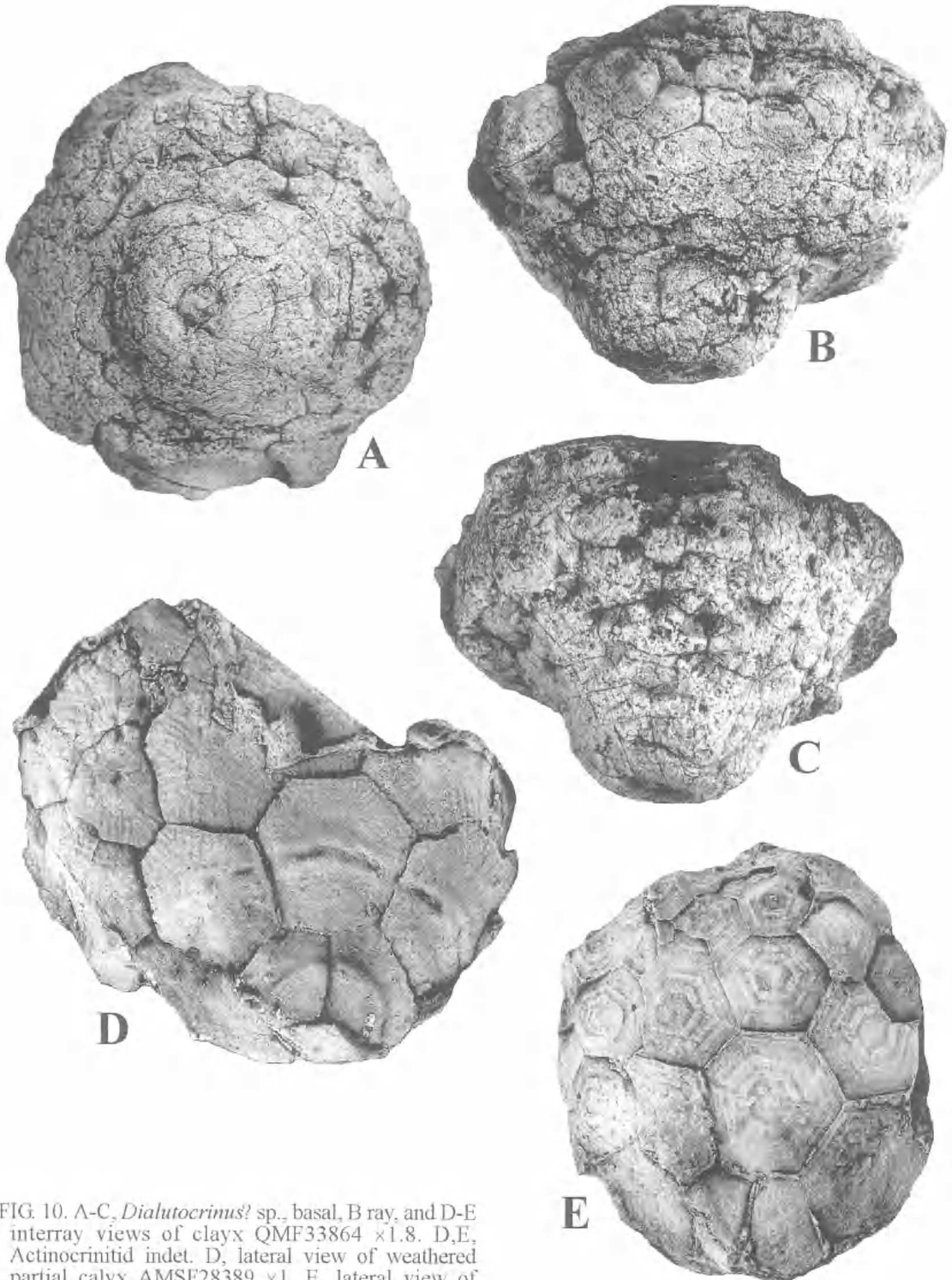


FIG. 10. A-C, *Dialutocrinus?* sp., basal, B ray, and D-E interray views of clayx QMF33864 $\times 1.8$. D, E, Actinocrinitid indet. D, lateral view of weathered partial calyx AMSF28389 $\times 1$. E, lateral view of exterior of AMSF27094 $\times 1.1$.



FIG. 11. *Dichocrinus* cf. *D. laudoni* Broadhead, 1981, lateral view of upright crown QMF38957, with *Seytalocrinid*? indet., lateral view of horizontal crown QMF38958 $\times 3$.

D. laudoni become cuncate, whereas the distal brachials of *D. cf. D. laudoni* are unknown. They probably become cuncate as this is a feature common to all uniserial species of the genus. If new material is found to show that the brachials do not become cuncate distally, this Australian specimen could represent a new species. In *Dichocrinus* only *D. cinctus* Miller & Gurley, 1890 and *D. fusiformis* Austin & Austin, 1844 have 10 arms, but both have surface ornament on the cup plates. All 3 of the 10-armed species of *Dichocrinus* are of middle or late Tournaisian age, suggesting a similar age for *D. cf. D. laudoni*.

The specimen is on a small slab associated with an indeterminate *seytalocrinid*? and a *rhodocrinid*.

Family ACROCRINIDAE Wachsmuth & Springer, 1885

Subfamily GLOBACROCRININAE
Moore & Strimple, 1969

***Denarioacrocrinus* gen. nov.**

TYPE SPECIES. *Denarioacrocrinus neerkolensis* gen. et sp. nov. from the late Namurian or early Westphalian part of the Neerkol Formation, near Stanwell, Queensland.

ETYMOLOGY. Latin *denarius*, containing 10; refers to the 10 distal intercalaries.

DIAGNOSIS. Calyx vase-shaped; basal circlet unknown; strongly rounded, angustary radial facets, sloping downward outward; minimum 5 rows of intercalaries; 10 plates in distal row, 1 in line with single anal, 3 in line with A, D and E radials, all others interradial; 4 arms per ray.

REMARKS. Moore & Strimple (1969) noted the explosive evolution in the acrocrinids in the Middle to Late Carboniferous of the midcontinent region of the United States. The Globacrocrininae retains the narrow radial facets and advanced genera have a flat basal circlet not visible in lateral view. Genera are defined mainly on the number of distal intercalaries. *Denarioacrocrinus*, with 10 distal intercalaries, is intermediate between the Morrowan to Desmoinesian *Globacrocrinus*, with 8, and the Missourian *Cauacrocrinus*, with 11 distal intercalaries. *Denarioacrocrinus* is the first Late Carboniferous globacrocrinid with part of the arms preserved. The 4 arms per ray are an advanced condition compared to the Early Carboniferous *Protacrocrinus* with 2 and *Springeracrocrinus* with 3.

***Denarioacrocrinus neerkolensis* sp. nov.**
(Fig. 12A-C)

ETYMOLOGY. From the Neerkol Formation.

MATERIAL. HOLOTYPE: GSQF10875a and b, internal and external thecal moulds from GSQK106, late Namurian or early Westphalian, Neerkol Formation.

DIAGNOSIS. As for genus.

DESCRIPTION. Calyx vase-shaped, 22.9mm long (incomplete), 16.5mm wide (slightly crushed), widest at midlength, suture flush, fine vermiform ornament. Basal circlet not preserved. Intercalaries mostly hexagonal, moderately large, minimum 5 rows. Distal row of intercalaries 10 plates, 3 in line with radials (A, D and E), 1 under anal, all others interradial. Distal intercalary next to anal series below C radial, 5.1mm long, 5.1mm wide (estimated), gently convex, subvertical. A and D

radials hexagonal, proximally adjoining 3 intercalaries; C and E radials pentagonal, proximally adjoining 2 intercalaries; E radial pentagonal with proximal tip adjoining distal tip of in line intercalary; all radials gently convex transversely, straight to slightly convex longitudinally, subvertical. C radial 4.7mm long, 6.3mm wide. Radial facet angustary, sloping downward outward, strongly convex externally, below radial summit, with transverse ridge. Anal plate large, hexagonal, 5.5mm long, 4.5mm wide, distal half in line with radials. Tegmen formed of small plates, projecting above radial summit. Arms slender, isotomously branching on 2nd primibrachs and 2nd secundibrachs, 4 per ray, 20 arms if all rays branch as C ray. Proximal brachials cuneate, convex longitudinally, strongly rounded transversely, horseshoe-shaped, with pinnule on long side. Distal brachials unknown, probably biserial.

REMARKS. This calyx is slightly distorted from compaction and lacks the basal circlet. The vase-shape, multiple rows of intercalaries and angustary radial facets are primitive features of the Globacrocrininae, whereas 4 arms per ray is an advanced feature. This was the first crinoid reported (McKellar, 1966) from the Late Carboniferous of Australia.

***Denarioacrocrinus?* ornatus** sp. nov.
(Fig. 12D-F; Table 2)

ETYMOLOGY. Latin *ornamentus*, ornament; referring to the stellate and granulate ornamentation.

MATERIAL. HOLOTYPE: GSQF10877a and b from GSQ334. PARATYPE: GSQF10876 from GSQ334, late Namurian or early Westphalian Neerkol Formation.

DIAGNOSIS. Alternating 6 rectangular and 6 hexagonal first row of intercalaries above the basals and stellate ornament on cup plates; sutures impressed.

DESCRIPTION. Calyx vase-shaped, widest at midlength. Bipartite basals horizontal, in basal impression, followed by 7 rows of intercalaries increasing in size distally. Sutures impressed. Plates mostly hexagonal after first row of alternating 6 rectangular and 6 hexagonal plates. Rows staggered with plates interlocking distally and proximally. Occasional pentagonal or heptagonal plate where interlocking adjusted for smaller plate. Plates with stellate ridge ornament radiating from centre of plate to all adjacent plates. Longitudinal ridge developed most strongly on basal

row of intercalaries. Fine nodose to vermiform ornament, nodes may be aligned to stellate ridges or sides of plates. First row of intercalaries horizontal, rectangular ossicles strongly convex longitudinally, hexagonal ossicles forming base of calyx; hexagonal plates distal tips visible in lateral view. All following intercalaries subvertical. Stem circular transversely; columnals with wide aureola, narrow crenularium, small ?pentagonal lumen.

REMARKS. GSQF10877a and b are the internal and external moulds of the base of one partial calyx up to the 3rd row of intercalaries. GSQF10876 is a partial calyx lacking the radials and tegmen. It is crushed along the anterior-posterior plane of symmetry.

D.? *ornatus* is distinguished from *D. neerkolensis* by the stellate ornament and plate arrangement of the 1st row of intercalaries. This is the 1st acrocrinid known with stellate ornamentation. Lacking the radials and complete row of distal intercalaries generic assignment must be questioned.

Suborder GLYPTOCRININA Moore, 1952
Superfamily PLATYCRINITOIDEA
Austin & Austin, 1842
Family PLATYCRINITIDAE
Austin & Austin, 1842

Platycrinites J.S. Miller, 1821

TYPE SPECIES. *Platycrinites laevis* Miller, 1821 from the Early Carboniferous of England; by subsequent designation of Meek & Worthen, 1865.

Platycrinites nux?
(Etheridge, 1892) nomen correctum
(Fig. 14I,J)

MATERIAL. GSQF10870, an internal mould from GSQ334, Viséan? Caswell Creek Group.

REMARKS. An internal mould of a cup, designated *Platycrinus?* *nux* by Etheridge (in Jack & Etheridge, 1892) and mentioned by Etheridge

TABLE 2. *Denarioacrocrinus?* *ornatus* sp. nov. measurements (mm).

	F10877	F10876
Calyx length		24.2
Calyx width		15.6
Diameter basal circlet (maximum)	6.9	
Diameter basal circlet (minimum)	5.9	
Intercalary 1 rectangular length	1.9	
Intercalary 1 rectangular width	1.8	
Intercalary 1 hexagonal length	3.2	
Intercalary 1 hexagonal width	2.7	
Intercalary 2 stem impression	2.4	

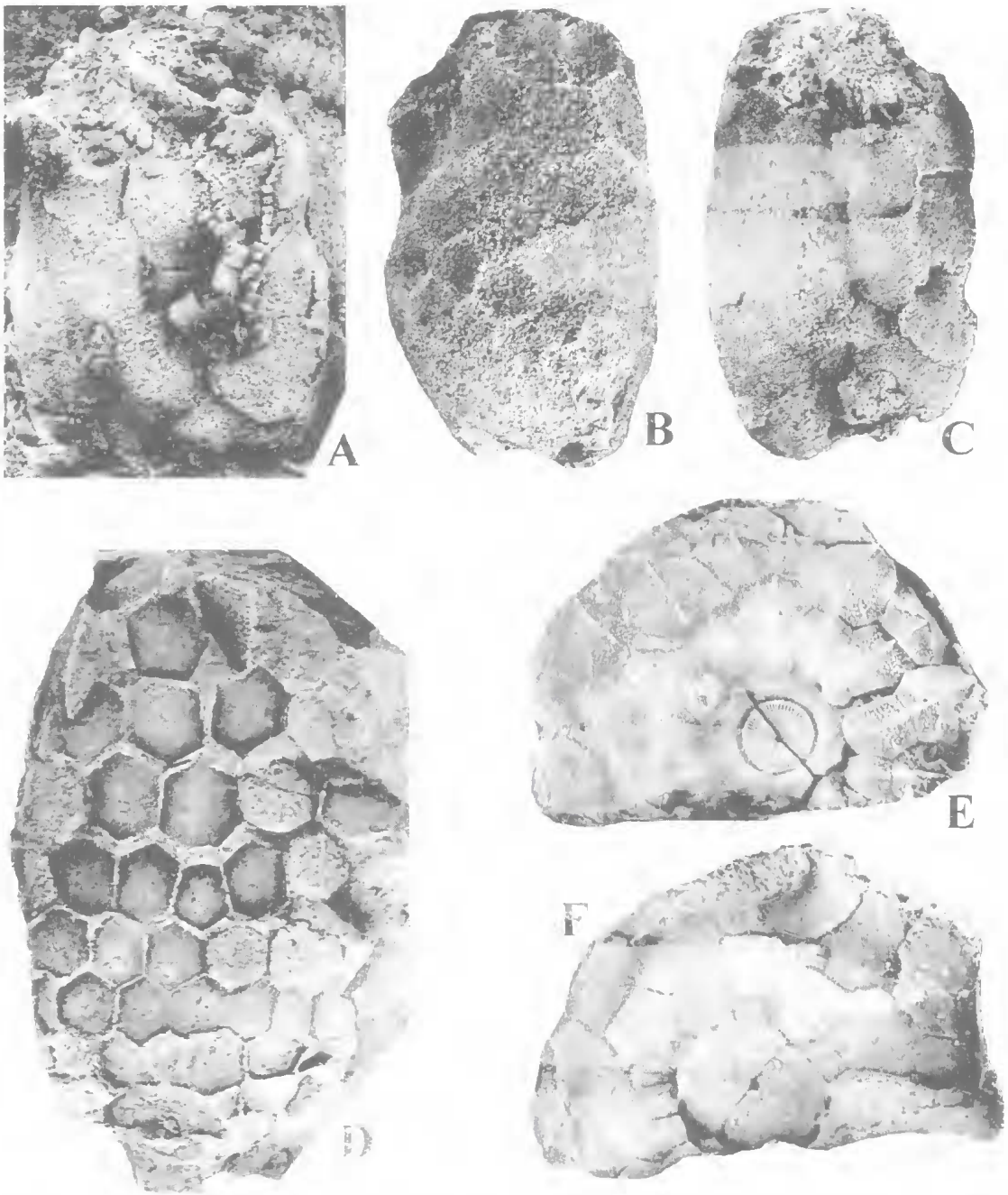


FIG. 12. A-C, *Denarioacocrinus neerkolensis* gen. et sp. nov., holotype GSQI 10875a and b, $\times 2.5$. A, posterior view of calyx. B, C, A ray and posterior views of internal mould. D-F, *Denarioacocrinus? ornatus* sp. nov., D, B-C interray view of calyx, paratype GSQF10876, $\times 3.3$. E-F, basal and interior view of holotype GSQF10877, $\times 3$.

(1892) has a high bowl-shaped basal circle and vertical elongate radials. An internal mould (GSQF10870) of a cup from the Early

Carboniferous Caswell Creek Group, near Old Camindah is nearly the same size, and has the same shape and plate pattern as the holotype

of these specimens in size and proportions, as well as the type of preservation, suggests that they are from the same stratigraphic unit. Etheridge (in Jack & Etheridge, 1892) reported the specimen from the Middle or Marine Series of the Bowen river Coal Field, 21°20'S, 148°30'E; this is in the Lizzie Creek Volcanics. We wonder if, for unknown reasons, the locality information given by Etheridge (in Jack & Etheridge, 1892) could be incorrect or if the specimen was reworked from Carboniferous deposits. Disarticulated unornamented plates described below as *Platycrinites* sp. 4 have radial ratios similar to those of this specimen.

Neither the new specimen described or that of Etheridge (in Jack & Etheridge, 1892) resolves the problem of the lack of ornamentation and other external features of the plates. Also, the tegmen and arms are unknown. It could be argued that *P. nux* is based on an internal mould and the surface ornament is unknown. However, future collections in these areas should provide additional specimens to support the acceptance of *P. nux*.

***Platycrinites testudo* Campbell & Bein, 1971**
(Fig. 13)

Platycrinus sp. Etheridge, 1892: 131, pl. 20, fig. 8.
Platycrinites testudo Campbell & Bein, 1971: 430, pl. 51, figs 10-21.
Platycrinites? crokeri Campbell & Bein, 1971: 433, pl. 49, figs 9-15; pl. 51, figs 3-4.
Platycrinites? sp. 1 Campbell & Bein, 1971: 434, pl. 51, figs 1-2.

MATERIAL. MMF33433, 33437, 33438, 33441, 33445-33452, 33607; AMS F59512, 59513, 59516, 65664, 104701, 104702 from the late Tournaisian Namoi Formation, near Barraba, NSW; collected by J. Irving.

REMARKS. The nodose ornament of previously illustrated specimens indicates the variation in *P. testudo*. New specimens from the Namoi Formation support this interpretation and show additional variation in the size and alignment of the nodes and ornamentation on the radials as well as the size and arrangement of the ornamentation on the tegmen plates.

The incomplete specimen illustrated by Etheridge (1892: 20, fig. 8) was described as 4 plates of a basal circlet, but it is 2 radials with distal tegmen plate and a proximal part of the basal circlet. The radial facet is visible on the radial to the right centre and the inverted V of the nodose ornament points to the facet on the radial to the left of centre.

***Platycrinites* sp. 1**
(Fig. 14F-H)

MATERIAL. MMF33440, 33442, 33443 and 33453 from the late Tournaisian Namoi Formation near Barraba, NSW.

DESCRIPTION. Cup bowl-shaped, 25mm long (crushed), 12-25.2mm wide (18.6 av.), fine granular or vermiform ornament. Basal circlet low conical, widely flaring; plates fused. Radials 5, 16, 1mm long, 13, 1mm wide, weakly convex longitudinally, gently convex transversely, shoulders flat to laterally sloping. Radial facet angustary, 5.4mm wide, crescent-shaped, moderately convex aborally. Primibract axillary, concave longitudinally, moderately convex transversely. Stem facet elliptical, relatively small, 3.4 × 4.4mm. Proximal columnal with convex latus. Arms, tegmen and stem unknown.

REMARKS. *Platycrinites* sp. 1 differs from *P. testudo* by lacking the coarse nodose ornamentation, having a more upflaring basal circlet and relatively smaller stem facet. It differs from *P.?* sp. 2 of Campbell & Bein (1971) by being more equidimensional, lacking the pustulose ornament and having shallower radial facets.

The specimens are all distorted and cracked from compaction.

***Platycrinites* sp. 2**
(Fig. 14A)

MATERIAL. QMF38946 from QML508, late Tournaisian, Malchi Formation.

DESCRIPTION. Radial large, 12.8mm long, 13.6mm wide, gently convex longitudinally and transversely, thin, with fine granular ornament; radial facet angustary, projecting outward from radial surface, deep, horseshoe-shaped, strongly convex outer edge, transverse ridge wide, gently rounded, ends elevated slightly.

REMARKS. The fine granular ornament of *Platycrinites* sp. 2 readily distinguishes it from *P. testudo*. The projected horseshoe-shaped facet is much deeper and more projected than that of *P.?* sp. 1. Lacking the rest of the cup and tegmen it is left in open nomenclature.

***Platycrinites* sp. 3**
(Fig. 14D,E)

MATERIAL. Basal circlet and partial radials QMF38947 and partial radial plate, QMF38948, from QML508, late Tournaisian, Malchi Formation.

DESCRIPTION. Basal circlet bowl-shaped, thin, unornamented; plates fused. Radial large,

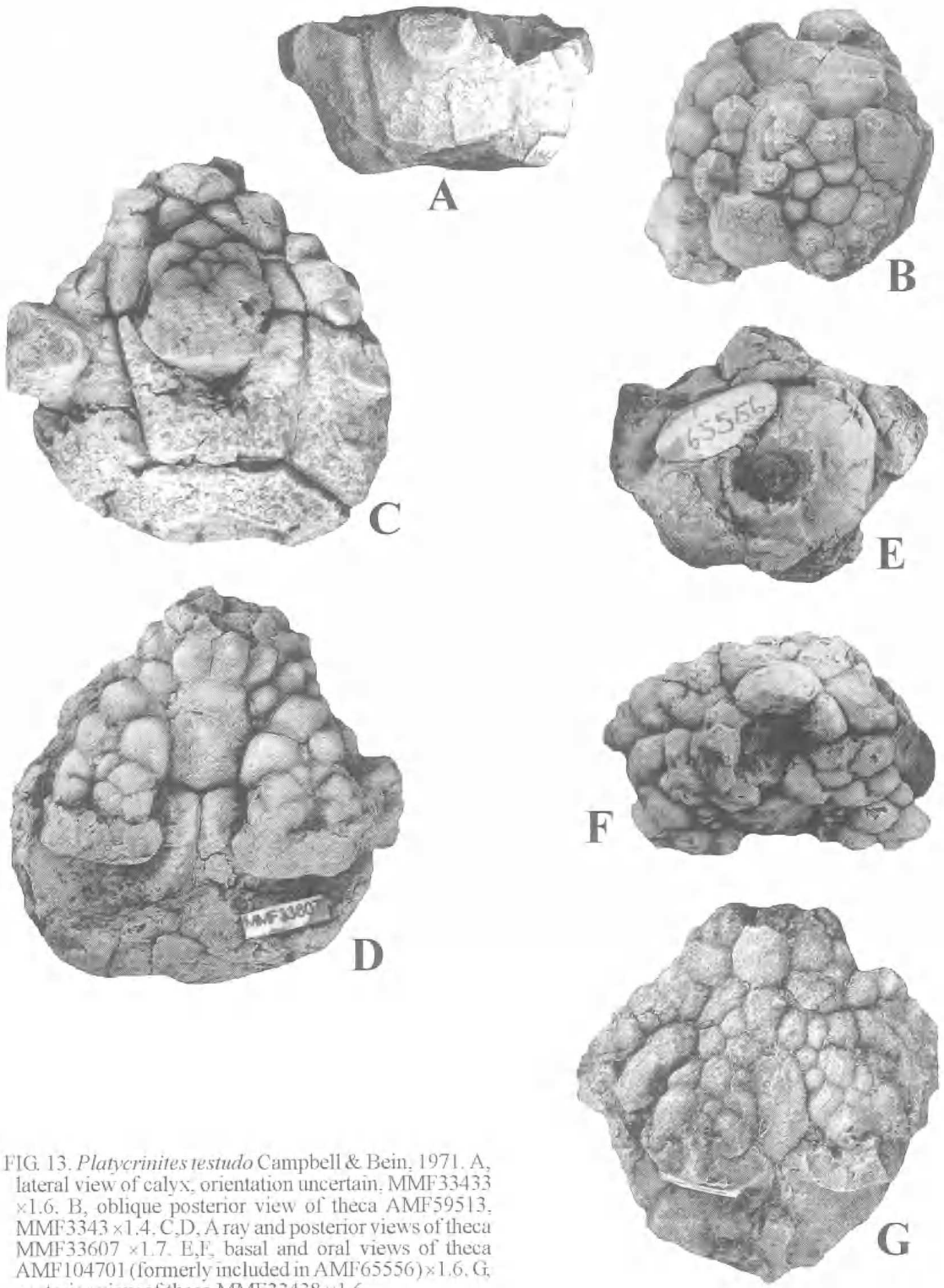


FIG. 13. *Platycrinites testudo* Campbell & Bein, 1971. A, lateral view of calyx, orientation uncertain, MMF33433 $\times 1.6$. B, oblique posterior view of theca AMF59513, MMF3343 $\times 1.4$. C, D, A ray and posterior views of theca MMF33607 $\times 1.7$. E, F, basal and oral views of theca AMF104701 (formerly included in AMF65556) $\times 1.6$. G, posterior view of theca MMF33438 $\times 1.6$.

15.5mm long (incomplete), 15.5mm wide, thin, smooth; angustary radial facet strongly convex outwardly, slightly elevated above radial surface, small inwardly pointed V-shaped ridges at outer ends of transverse ridge. Stem facet small, 2.0 × 2.4mm, elliptical outline, with narrow crenularium.

REMARKS. *Platycrinites* sp. 3 differs from *P. testudo*, *P.* sp. 1 and *P.* sp. 2 by lacking ornament. The specimens are fractured and incomplete. They are illustrated to show the variation in the platycrininids of eastern Australia.

Platycrinites sp. 4
(Fig. 14B,C)

MATERIAL. Partial basal circlet QMF38949 and partial radials QMF38950 from QML508, late Tournaisian, Malchi Formation.

REMARKS. The basal circlet is an internal mould with the bare edges of parts of the exterior surface. It is uncrushed, high conical and thin. The thin partial radials are very elongate, unornamented and straight longitudinally. These specimens, if from one species, would have similar shape and proportions to *P. mix*, and the specimen would be tentatively referred to *P. mix* from the Caswell Creek Group.

Camerate indet.

Crinoid calyx Etheridge in Jack & Etheridge, 1892: 210, pl. 44, fig. 8.

MATERIAL. QMF1194, late Tournaisian ?Malchi Formation, Rockhampton District. Collected by C.W. De Vis.

REMARKS. The weathered internal mould of a partial calyx reported by Etheridge (in Jack & Etheridge, 1892) is an indeterminate camerate. Plate sutures are indistinguishable but the long tegmen shows parts of the ambulacral trackways of two rays. Etheridge (in Jack & Etheridge, 1892) reported the specimen from the Gympie Beds, now considered to probably be from the Malchi Formation.

Subclass DISPARIDA Moore & Laudon, 1943
Superfamily ALLAGECRINOIDEA Carpenter
& Etheridge, 1881
Family ALLAGECRINIDAE
Carpenter & Etheridge, 1881

Litocrinus Lane & Sevastopulo, 1982

TYPE SPECIES. *Kallimorphocrinus punctatus* Lane & Sevastopulo 1982 from the Viscaan New Providence Shale of Tennessee; by original designation.

Litocrinus sp.
(Fig. 15D-F)

MATERIAL. QMF39022, 39075 from QML878, Viscaan Baywulla Formation.

DESCRIPTION. Cup conical, 0.65mm long, 0.8mm wide. Basal circlet fused, 0.15mm long, 0.5mm wide. Radials straight longitudinally, moderately convex transversely, moderately flaring; radial facets convex outward, subhorizontal. Small anal notch. Oral circlet moderately arched. Orals 5, concave; posterior oral larger, separating BC and DE orals.

REMARKS. The cup of QMF39022 is coated with small secondary crystals masking plate sutures and giving the specimen a false ornament. The specimen has a higher basal circlet than *L. scoticus* and is not as elongate as *L. extensus*, both described from the Viscaan of Scotland (Wright, 1932, 1952). It is not as elongate as *L. angulatus* and *L. tintinabulum*, both from the Viscaan Nunn Shale of New Mexico (Strimple & Koenig, 1956). It also lacks the concave cup walls of *L. protuberans* and *L. pansus*, both reported from the Permian of Western Australia (Webster & Jell, 1992). It may represent a new species, but is an inappropriate specimen to serve as a type. The smaller immature specimen QMF39075, is 0.55mm long and 0.45mm wide, weathered and shows poor plate margins. This is the first report of *Litocrinus* from the Carboniferous of Australia.

Superfamily BELEMNOCRINOIDEA
S.A. Miller, 1883
Family SYNBATHOCRINIDAE
S.A. Miller, 1889

Synbathocrinus Phillips, 1836

TYPE SPECIES. *Synbathocrinus conicus* Phillips, 1836 from the Tournaisian of England; by monotypy.

Synbathocrinus ogivalis de Koninck, 1878
(Fig. 15A-C)

Synbathocrinus ogivalis de Koninck, 1878: 158, pl. 6, figs 1-1b; 1898: 121, pl. 6, figs 1-1b. Bassler & Moody, 1943: 696.

Synbathocrinus sp. Campbell & Bein, 1971: 424, pl. 49, figs 16-21, text-fig. 5. Webster, 1977: 164.

MATERIAL. MMF33432 from the late Tournaisian Namoi Formation near Barraba, NSW.

DESCRIPTION. See de Koninck (1878, 1898) and Campbell & Bein (1971).

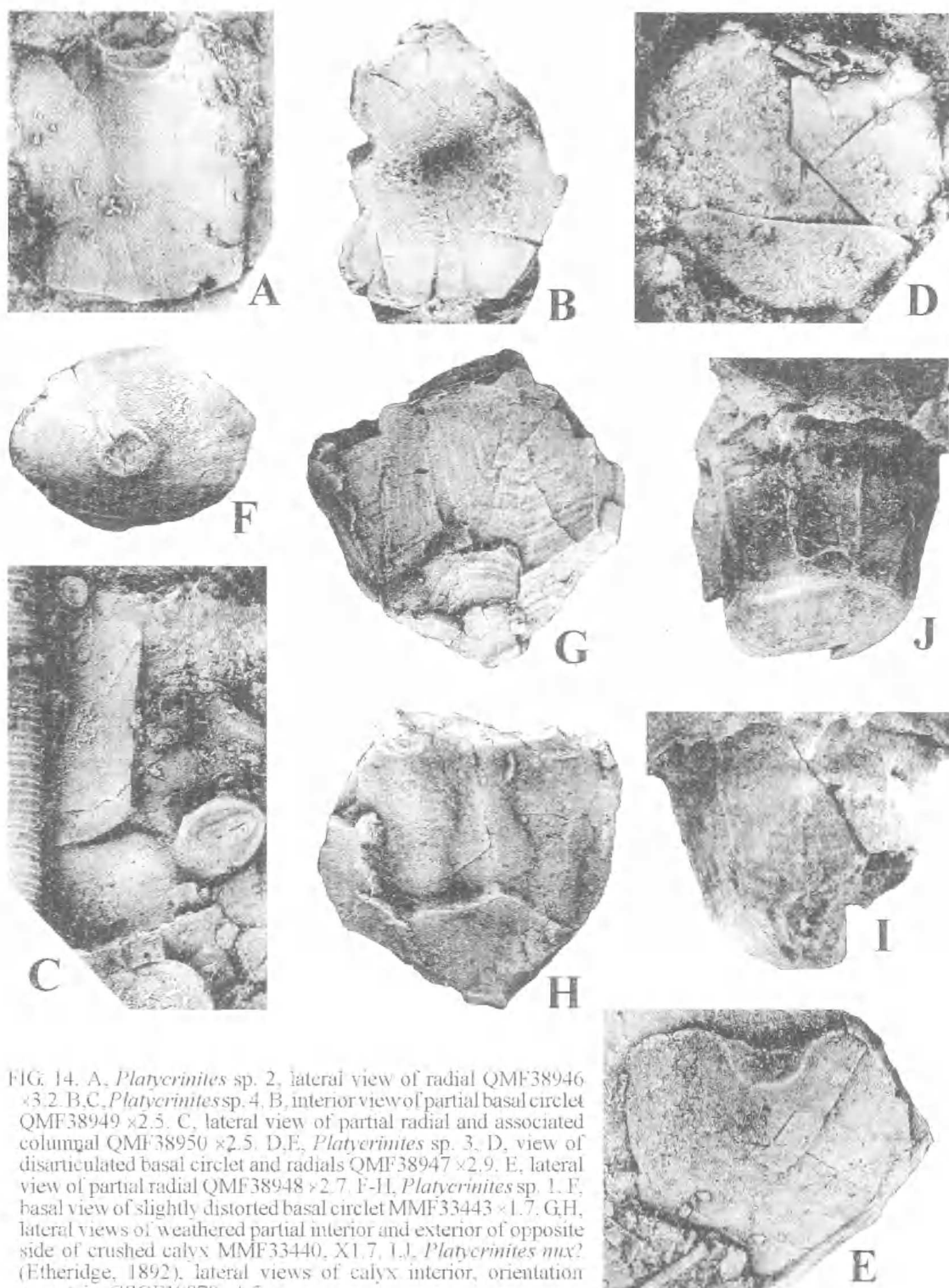


FIG. 14. A, *Platycrinites* sp. 2, lateral view of radial QMF38946 $\times 3.2$. B, C, *Platycrinites* sp. 4, B, interior view of partial basal circlelet QMF38949 $\times 2.5$. C, lateral view of partial radial and associated columgal QMF38950 $\times 2.5$. D, E, *Platycrinites* sp. 3, D, view of disarticulated basal circlelet and radials QMF38947 $\times 2.9$. E, lateral view of partial radial QMF38948 $\times 2.7$. F-I, *Platycrinites* sp. 1, F, basal view of slightly distorted basal circlelet MMF33443 $\times 1.7$. G, H, lateral views of weathered partial interior and exterior of opposite side of crushed calyx MMF33440, X1.7. I, J, *Platycrinites* *mx?* (Etheridge, 1892), lateral views of calyx interior, orientation uncertain, GSQF10870 $\times 1.5$.

REMARKS. *Synbathocrinus ogivalis* was reported by de Koninck (1878) from an unknown horizon at Burrageood, Paterson River, NSW. As noted by Campbell & Bein (1971), it probably came from the Lower Carboniferous. De Koninck's original description is minimal and his illustrations are stylised. However, they are sufficient to define and recognise the species. De Koninck (1878) mistakenly reported the basal circle to be a single plate for all species of *Synbathocrinus* including *S. ogivalis*, whereas Campbell & Bein (1971) showed 3 plates in their *S. sp.* Both de Koninck's (1878) and Campbell and Bein's (1971) descriptions are considered correct for the specimens investigated and show the variation in *S. ogivalis*. The basal circle of *Synbathocrinus* is highly variable within most species known from multiple specimens. Webster & Lane (1987) reported the basal circle of 2 undescribed species in the late Tournaisian Anchor Limestone of southern Nevada to vary from 1-4 plates. Two Artinskian species from Western Australia (Webster, 1987) varied from 1-4 plates in *S. campanulatus* and from 1-3 in *S. constrictus*. The specimen illustrated herein has 3 plates in the basal circle, with the EA basal azygous, but the sutures are difficult to define, because of partial fusing and recrystallisation.

The type specimen of *S. ogivalis* is presumed lost in the Garden Palace fire of 1886. Therefore, ANU18893, (Campbell & Bein, 1971, pl. 49, figs 16-18) is designated the neotype.

Subclass CLADIDA Moore & Laudon, 1943
Order CYATHOCRINIDA Bather, 1899
Superfamily CYATHOCRINITOIDEA
Bassler, 1938
Family EUSPIROCRINIDAE Bather, 1890

***Neerkolocrinus* gen. nov.**

TYPE SPECIES. *Neerkolocrinus typus* from the Westphalian Neerkol Formation, Rockhampton.

ETYMOLOGY. For the Neerkol Formation.

DIAGNOSIS. Crown robust, expanding gently distally; cup medium to high bowl-shaped, with upflared basals; plate inflated, with stellate ridge ornament on basals and radials and fine node ornament on cup plates continuing on brachials; 5 anals in cup; prominent anal tube tapering distally above posterior interray; at least 10 arms, branching isotomously on 6th primibrach; at least one ramule on 3rd secundibrach in some rays; brachials rectilinear, strongly rounded transversely, lacking pinnules.

REMARKS. *Neerkolocrinus* shows some relationship to both euspiroerinids and botryocrinids. Genera assigned to both the euspiroerinids and botryocrinids have a conical or bowl-shaped cup, lacking stellate ornamentation and 1-4 anals. The presence of the proximal 1/2 of the first 2 tube plates below the radial summit does not alter the number of anals in the eup significantly, but is considered a primitive condition. First branching of the arms on the 6th primibrach is also considered a primitive condition for such a young form of euspiroerinid or botryocrinid. The tapered anal tube above the posterior interray is present in some euspiroerinids (*Euspirocrinus* and *Parisocrinus*), whereas most botryocrinids have longer or recurved anal tubes. The radial is beneath or below to the left of the C radial in most euspiroerinids and botryocrinids. Botryocrinids typically have ramules and the brachials lack cover plates, which euspiroerinids and *Neerkolocrinus* have. Muscular articulation and an internal axial canal in the brachials of *Neerkolocrinus* also show relationships to the euspiroerinids rather than the botryocrinids.

Euspiroerinids may be divided into 3 groups based on cup shape. *Ampheristocrinus*, *Clostero-crinus*, *Parisocrinus* and *Zygotocrinus* have narrow, long cone-shaped cups. *Caelocrinus* and *Vasocrinus* have short conical to bowl-shaped cups and *Euspirocrinus* and *Neerkolocrinus* have long wide bowl-shaped cups. *Neerkolocrinus* is distinguished from *Euspirocrinus* by the more bowl-shaped cup, more distal 1st branching of the arms, stellate ridge ornament and continuation of fine node ornament onto the brachials.

***Neerkolocrinus typus* sp. nov.**
(Figs 16, 17A, B)

ETYMOLOGY. Latin *typus*, model or example; the type species.

MATERIAL. HOLOTYPE: GSQF10872 from GSQLK106, late Namurian or early Westphalian Neerkol Formation.

DIAGNOSIS. As for genus.

DESCRIPTION. Crown robust, elongate, flaring upward gently, 43.9mm long (incomplete), 19.4-23mm wide (21.2mm av.). Cup medium high bowl-shaped, plates inflated, 17.6mm long, 13.6-23mm wide (18.3mm av.); ornament of stellate ridges to adjoining plates on basals and radials, ray ridges more strongly developed than non-ray ridges; fine granular nodes with some alignment parallel to plate margins, nodes continuing on all brachials. Infrabasal circle diameter 11.8mm

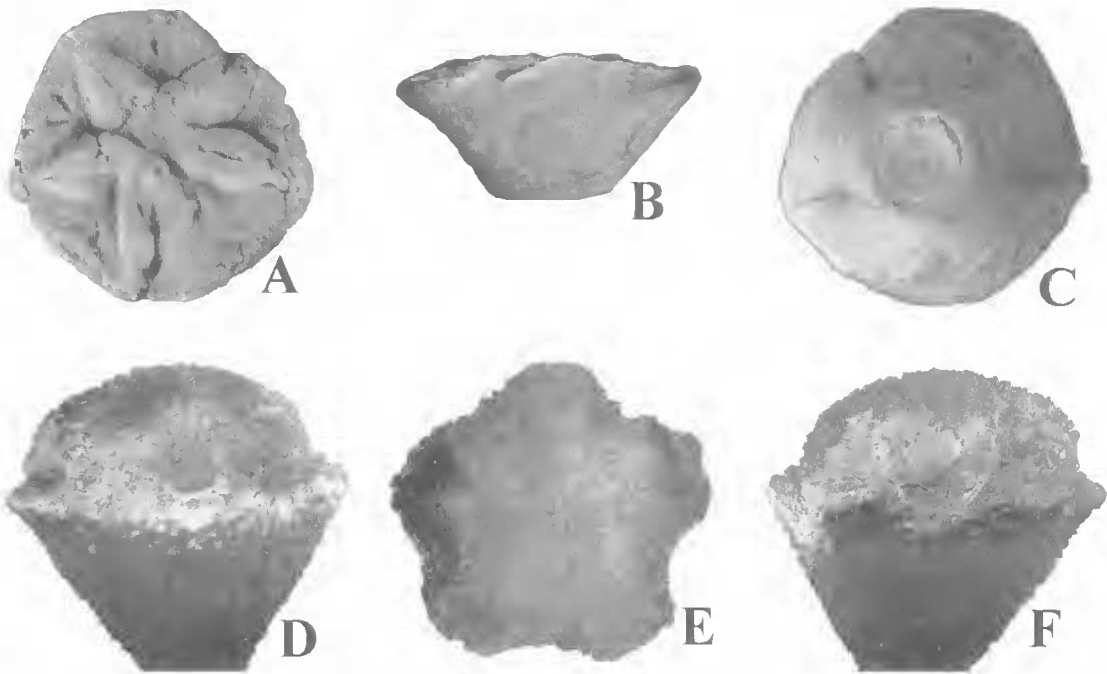


FIG. 15. A-C, *Synbathocrinus ogivalis* de Koninck, 1878, oral, posterior and basal views of cup MMF33432 $\times 4.2$. D-F, *Liticrinus* sp., A ray, oral and posterior views of cup QMF39022 $\times 50$.

internally. Infrabasals 5, slightly inflated, forming base of cup, upflared, visible in lateral view, distal tips forming base of cup walls. Basals 5, equidimensional, 9.5mm long and wide, moderately convex longitudinally and transversely, hexagonal: BC basal heptagonal supporting primanal on left shoulder; CD basal octagonal supporting first and second anals on right side and shoulder. Radials 5, slightly wider (10.2mm) than long (9.1mm), moderately convex longitudinally and transversely, subvertical to slightly incurved. Radial facet angustary, horseshoe-shaped, strongly declivate. Anals 5 in cup. Primanal pentagonal, below and left of C radial, also adjoining BC and CD basals, 2nd and 3rd anals. Second anal largest, hexagonal, adjoining primanal, CD basal, D radial, 2 anal tube plates and 3rd anal. Basal 1/2 of 4th and 5th anals below summit of radial facets. Anal tube extending well above radial summit over posterior interray, tapering distally. Arms at least 10, if isotomous branching in all rays on 6th primibrachs as in D and E rays. Brachials uniserial, rectilinear, strongly convex transversely, wider than long proximally, distally subcircular transversely, nonpinnular; primibrachs 3.2mm long, 5.5mm wide. Third secundibrach giving off ramule in D ray. All brachial facets with transverse ridge

across approximate middle of faect, deep transversely elongate ligament pit on outer margin, very small internal axial canal in middle of transverse ridge, elevated adoral area between transverse ridge and ambulacral groove, large muscle areas on inner margins, triarthrial articulation. Ambulacral groove deep V-shaped, notched on both sides; small cover plates not preserved.

REMARKS. The type is preserved as external and internal moulds of a partial crown compressed along the A-CD plane of symmetry.

Kopriacrinus gen. nov.

TYPE SPECIES. *Kopriacrinus mckellari* gen. et sp. nov. from the Westphalian Neerkol Formation, W of Rockhampton.

ETYMOLOGY. Greek *Kopria*, dunghill; refers to the appearance of the cup as a cluster of pellets or a composite fecal pellet.

DIAGNOSIS. Crown small; cup high cone-shaped; plates inflated; sutures impressed, apical pits; radial facet angustary, declivate; 3 anals; tegmen plates large, minimum 10; quadrate orals separated by large ambulacrals; tegmen subhorizontal or projecting slightly above radial

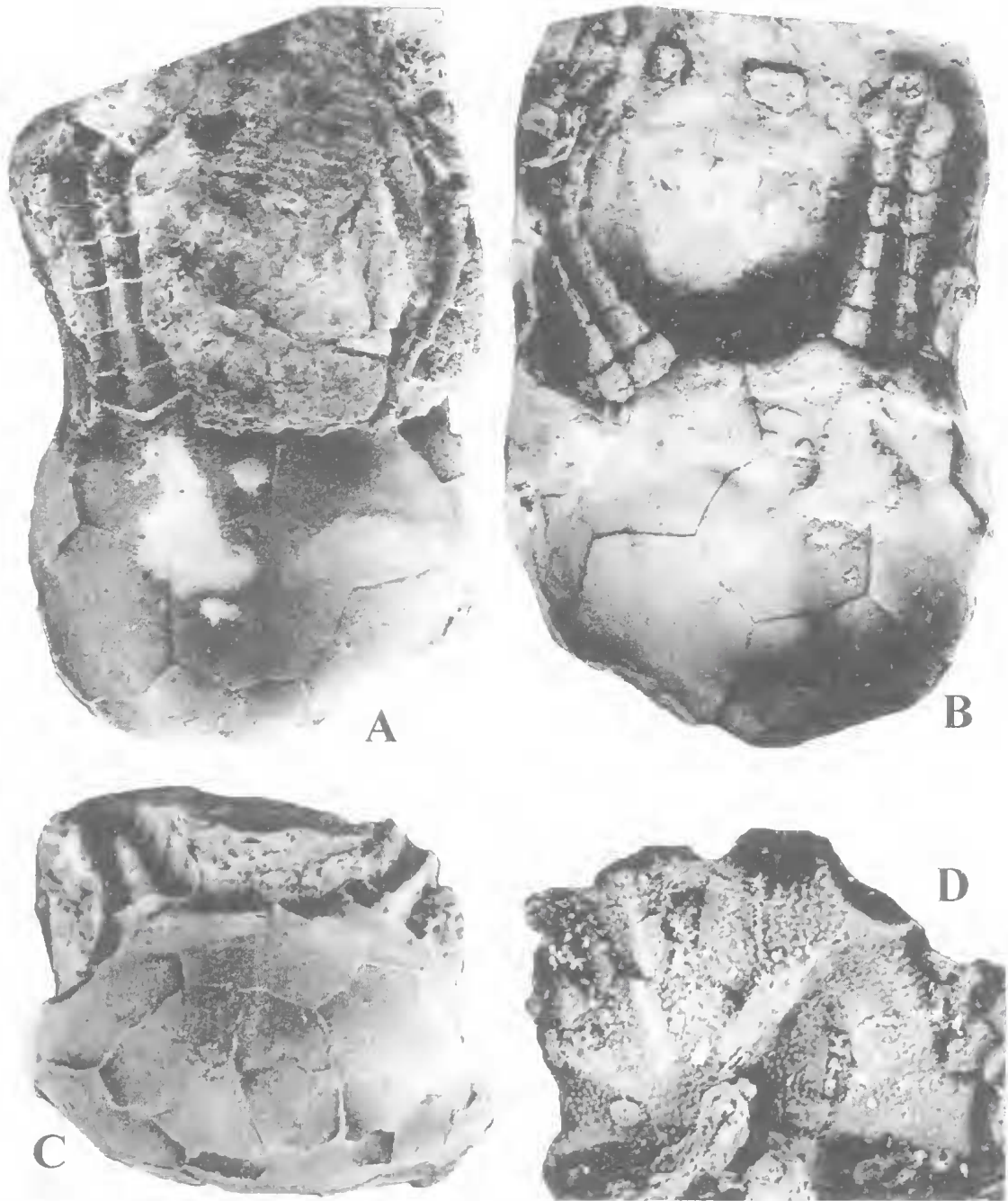
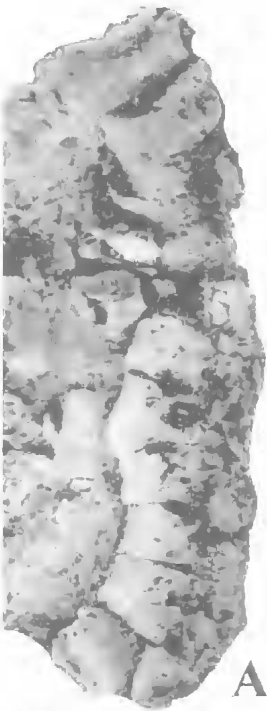


FIG. 16. *Neerkolocrinus typus* gen. et sp. nov., holotype, GSQF10872. A, B-C interray view of internal mould $\times 2.8$. B, D-E interray view of external mould $\times 2.8$. C, basal view of internal mould $\times 2.9$. D, C ray view of external surface of cup $\times 3.9$.

FIG. 17. (Opposite) A, B, *Neerkolocrinus typus* gen. et sp. nov., holotype, GSQF10872. A, lateral view of external surface of partial arm $\times 3.7$. B, D-E interray view of internal mould $\times 2.8$. C-E, *Kopriacrinus mckellari* sp. nov. C, D, internal $\times 3.5$ and external $\times 4.7$ views of paratype GSQF10874. E, C ray view of cup with associated brachial fragments, holotype GSQF10873 $\times 3.7$.



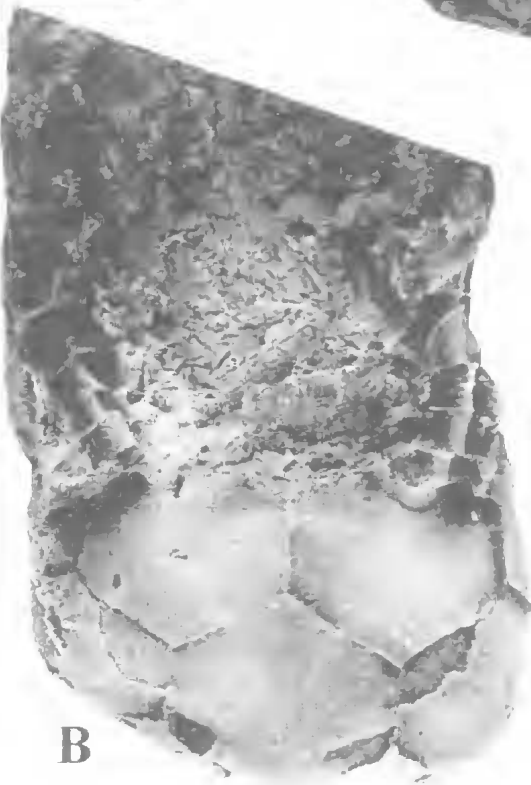
A



C



E



B



D

summit; at least 10 arms; retilinear brachials strongly rounded transversely; stem transversely pentagonal, heteromorphic.

REMARKS. Except for the pentagonal stem *Kopriacrinus* fits the Euspirocrinidae, which were defined by Lane & Moore (in Moore & Teichert, 1978) as having a round stem. Phylogenetic significance of this feature is uncertain, but may imply a polyphyletic origin of the family. *Kopriacrinus* differs from all genera in the family by one or more other morphologic features. It is most similar to *Vasocrinus*, which differs by having a low conical cup with large axial canals in the brachials and radials.

***Kopriacrinus mckellari* sp. nov.**
(Fig. 17C-E: Table 3)

ETYMOLOGY. For R.G. McKellar in recognition of his contributions to the geology of Queensland.

MATERIAL. HOLOTYPE: GSQF10873. PARATYPE: GSQF10874 from GSQ L K106, late Namurian or early Westphalian Neerkol Formation.

DESCRIPTION. Crown small, cylindrical to slightly expanding distally. Cup high cone shaped, with inflated plates, sutures impressed, apical pits. Infrabasal circle with shallow invagination for pentagonal stem facet. Infrabasals 5, proximally horizontal, distally upflared forming base of cup wall, visible in lateral view, bulbous, strongly convex longitudinally and transversely. Basals 5, hexagonal, wider than long, straight longitudinally, moderately convex transversely, inflated, surface irregular; BD and CD basals heptagonal, with extra side adjoining anal plates. Radials 5, pentagonal, wider than long, strongly convex longitudinally and transversely, inflated, surface irregular. Radial facet angustary, declivate, projecting out from radial, horseshoe-shaped, with faint transverse ridge. Anals 3: radianal large, adjoining BC and CD basals, inflated. Anal X and right tube plate probably projecting above radial summit. Tegmen plates large, at least 10. Orals quadrat, filling radial notches, abutting large ambulacrals adorally. Ambulacrals large, expanding adorally, with longitudinal ridge. Tegmen subhorizontal or projecting slightly above radial summit. Anal tube unknown. Rectilinear brachials horseshoe-shaped transversely, straight to slightly concave longitudinally, with deep V-shaped ambulacral groove, with facets for cover plates. At least one isotomous branching of arms; probably 10 arms. Stem transversely pentagonal, heteromorphic. Noditaxis pattern N1. Columnals with large lumen, strongly convex laterally.

REMARKS. The smaller holotype is an external mould of a slightly crushed cup with some associated brachials, whereas the larger paratype is an external and internal mould of a crown with disarticulated arm plates adjacent to the cup and 28.0mm of stem. The well-developed bulbous infrabasals are nearly equidimensional on the holotype, but longer than wide on the paratype.

The holotype is compressed along the AB-posterior interarray/D plane. The paratype is compressed along the A-CD plane of symmetry.

Order POTERIOCRINIDA Jaekel, 1918
Superfamily POTERIOCRINITOIDEA
Austin & Austin, 1842
Family POTERIOCRINITIDAE
Austin & Austin, 1842

****Poteriocrinites*? *smithii* (Etheridge, 1892)**
(Fig. 18)

Poteriocrinus? *smithii* Etheridge in Jack & Etheridge, 1892: 209, pl. 8, fig. 1.

Poteriocrinites smithii Etheridge; Bassler & Moodey, 1943: 645. Branson, 1948: 209.

MATERIAL. Plasticine cast BME15661 and plaster cast GSQF1590 stratigraphic unit uncertain, possibly from the Rockhampton Group, near Stanwell, Queensland.

DESCRIPTION. Crown elongate, 33.0mm long, 21.2mm wide (arms flaring distally). Cup bowl-shaped, with stellate ridge ornament on basals and radials. Infrabasal circle large, proximally horizontal, bearing stem facet, distally upflared, probably formed of 5 plates. Basals large, strongly convex longitudinally and transversely, forming base of eup walls; BC basal 3.9mm long, 2.9mm wide (estimated). Radials large, 2.1mm long, 4.0mm wide (estimated), moderately convex longitudinally and transversely, subvertical, with wide laterally sloping shoulders distally. Radial facet angustary, 1.7mm wide, with strongly convex outer rim, declivate, with radiating crenulae and eulmina on outer margin. Radial notches wide. Anals 3, convex longitudinally and

TABLE 3. *Kopriacrinus mckellari* measurements (mm).

	Holotype F10873	Paratype F10874
Cup length	8.4	9.4
Cup width (maximum)	7.0	10.4
Infrabasal circle diameter	5.0	5.2
Basal length	3.1	5.8
Basal width	3.1	5.0
Radial length	3.8	4.4
Radial width	3.7	6.7
Stem diameter		3.3

transversely. Radial below C radial, pentagonal. 2.8mm long. 1.7mm wide. adjoins C radial. BC basal, infrabasal cirelet, CD basal and anal X. Anal X hexagonal, large, length 2.5mm, width 2.0mm, adjoins C radial, radial, infrabasal cirelet. CD basal, D radial, right tube plate. Right tube plate rectangular, in radial cirelet above anal X. Stellate ridges sharply elevated; 4 ridges radiating from the B radial downward, 2 onto each subjacent basal; 3 ridges radiating from the C radial downward, 1 each onto BC basal, radial, anal X. One subhorizontal ridge extending laterally from anal X onto radial to right and CD basal to left.

Braehials slightly euncate, narrow, straight longitudinally, strongly convex transversely, horseshoe-shaped transversely, with 1 very slender pinnule on long side, with medium nodes on exterior. First branching isotomous on 2nd primibrach and exotomous on 2nd secundibrach in 2 rays visible. Arms 3 per ray. 15 if all rays branch in same manner. Stem circular transversely, heteromorphic, 1.5mm diameter, 37.0mm long, incomplete. Noditaxis N3231323 proximally, N₇ distally; nodals cirrate, multiple cirri per nodal. Columnals wide, with well rounded latus. Cirri small, homeomorphic, transversely round.

REMARKS. The description differs considerably from that of Etheridge (in Jack & Etheridge, 1892) in recognition of the infrabasal cirelet and anals. Plate sutures are difficult to determine on the casts, but are visible with magnification as the stellate ridges are slightly offset. The original interpretation is that the visible part of the cup consists of 2 partial radials, 1 on either side of a centrally complete radial; the underlying very wide basals are fractured and only the distal tips of 2 of the infrabasals are visible at the top of the stem. If this interpretation is correct, then the stellate ridge ornament varies considerably on the different radials and basals. The consistency in the stellate ridge ornament is accounted for in the new interpretation.

The specimen is not a *Poteroicrinites*. It probably represents a new genus of the Poteroicrinidae, based on the arm branching pattern and cup ornament, both of which differ significantly from all other genera assigned to the family. In hopes the original will be found or other specimens discovered we do not alter the original citation.

Etheridge (in Jack & Etheridge, 1892) reported the specimen to be an impression in a hard sandstone. Attempts to locate the original specimen failed but resulted in location of the materials listed above. The original specimen is apparently



FIG. 18. *Poteroicrinites?* *smithii* (Etheridge, 1892). C ray view of plasticine cast of holotype, BME15661 $\times 1.7$.

lost. A note with the plaster cast, GSQF1590, reported the original specimen was loaned to F.A. Bather and returned to the Geological Survey of Queensland in 1915 with three plaster casts, only one of which remains. Etheridge's figure was drawn from an earlier cast, perhaps one of the two plasticine casts in the British Museum (E15661).

The stratigraphic position of *P.?* *smithii* is uncertain. Etheridge (in Jack & Etheridge, 1892) reported the specimen from the Gympie Beds in the vicinity of Stanwell. As mapped by Dunstan

(1898) the Gympie Formation was the widespread basal unit of the Carboniferous in the Stanwell area. Currently, the Gympie Group is restricted to the Middle Permian of the Gympie Block (Day et al., 1982) and not recognised in the Stanwell area. There are several fossiliferous horizons in the Carboniferous and Permian in the vicinity of Stanwell. Without the original specimen the lithology cannot be matched and age of the specimen is in question.

Superfamily SCYTAOCRINOIDEA

Moore & Laudon, 1943

Family SCYTAOCRINIDAE

Moore & Laudon, 1943

Prininoerinus Goldring, 1938

TYPE SPECIES. *Prininoerinus robustus* Goldring, 1938 from the Late Devonian of Canada; by original designation.

REMARKS. The A ray of the holotype of *Prininoerinus robustus* lacks the arm above the 1st primibrach and Goldring (1938) noted that 3 other rays branch on the 2nd primibrach. Furthermore, she described one of the paratypes as having 3 primibrachs in one ray, which could be the A ray. Orientation of the specimen did not allow unquestioned identification of the ray. Thus, it is unknown if *Prininoerinus* has an atomous A ray or branched at some level above the 3rd primibrach. An atomous A ray is a primitive character of some Scytalocrinidae (*Histoerinus*, *Hypselocrinus*) among other primitive inadaunates. However, it is not an invariable character, as the A ray branches (often on primibrach 6 or higher) on some species assigned to these genera. Although listed under the Scytalocrinidae *Prininoerinus* was incorrectly placed in synonymy with *Scytalocrinus* (Moore & Strimple, in Moore & Teichert, 1978:640), as the arms of *Scytalocrinus* branch on the single primibrach in all rays. *Prininoerinus* is here accepted and considered to have an atomous or branched A ray.

Prininoerinus namoiensis sp. nov.

Histoerinus sp. Campbell & Bein 1971: 423, pl. 50, figs 8-9, text-fig. 4.

ETYMOLOGY. From the Namoi Formation.

MATERIAL. HOLOTYPE: ANU21344 from the late Tournaisian Namoi Formation, Crinoid Creek, near Burraba, NSW.

DIAGNOSIS. Crown slender, elongate; cup low bowl-shaped, distal tips of basals visible in lateral view; 3 anals in cup; radial facets plenary;

brachials strongly convex transversely, rectilinear, isotomous branching on 2nd primibrach in all rays except atomous A ray; pinnules very slender, elongate.

DESCRIPTION. See Campbell & Bein (1971: 423)

REMARKS. The partial crown assigned to *Histoerinus* by Campbell & Bein (1971) is reassigned to *Prininoerinus* because the brachials are rectilinear not cuneate as in *Histoerinus* (Kammer & Ausich, 1992). *Prininoerinus namoiensis* has a low bowl-shaped cup with the distal tips of the infrabasals visible in lateral view, 3 anals in the cup and rectilinear strongly rounded brachials. *P. namoiensis* differs from *P. robustus* by having a slightly shorter cup, less robust arms and more slender pinnules. The infrabasals, essentially confined to the basal plane of the cup (except for the distal upflared tips), and the intermediate position of the 3 anals (primanal moved wholly or partly into the CD interray position) are slightly advanced conditions in *P. robustus* and *P. namoiensis*.

Scytalocrinid? indet.

(Fig. 11)

MATERIAL. QMF38958, locality and horizon unknown in NSW, probably late Tournaisian Namoi Formation. Collected by G.M. Philip

DESCRIPTION. Cup small, truncated cone-shaped, no ornament. Infrabasal circlet forming truncated base proximally, weakly flared distally forming lower 1/4 of cup wall. Basals subequal length and width, straight longitudinally, gently convex transversely, gently flaring distally; CD basal truncated distally for reception of anal X. Radials gently flaring longitudinally, moderately convex transversely. Radial facet plenary, projecting slightly. Primibrach widest at base, blade-shaped proximally, constricted medially, strongly convex transversely shortly distal to base, concave longitudinally; distal end unknown. Proximal stem heteromorphic, with noditaxis N1, becoming homeomorphic distally. Columnals circular transversely; latus strongly convex.

REMARKS. This small partial crown is crushed and the cup plates are partly disarticulated with the proximal end of the radial covered by sub-adjacent basals. The truncated end of the CD basal is narrow, suggesting there was a radianal to the lower right of anal X and 3 anals in the cup. Cup and primibrach shapes, in conjunction with the

plenary radial facet, suggest affinity with Scytalocrinidae such as *Hydriocrinus* and *Hypselocrinus* but without the arms and anal series no generic assignment can be made. The specimen is associated with an unnamed new genus of rhodocrinitid and *Dichocrinus* cf. *D. laudoni* on a small slab.

Superfamily ERISOCRINOIDEA Wachsmuth & Springer, 1886

Family GRAPHIOCRINIDAE Wachsmuth & Springer, 1886

Holcoocrinus Kirk, 1945

TYPE SPECIES. *Graphiocrinus longicirifer* Wachsmuth & Springer, 1890 from the Tournaisian Hampton Formation, Iowa; by original designation.

Holcoocrinus barrabaensis sp. nov.
(Fig. 19)

ETYMOLOGY From Barraba, NSW.

MATERIAL. HOLOTYPE: MMF33608 (AMSF59510 and 59511 are casts of the type) from the late Tournaisian Namoi Formation, Crinoid Creek, near Barraba, NSW; found by J. Irving.

DIAGNOSIS. Crown elongate; cup truncated medium conc. primibrachs axillary, intermediate length; brachials intermediate length, moderately cuneate; unornamented.

DESCRIPTION. Crown elongate, 54.9mm long (incomplete), 21.5mm wide. Cup truncated medium conc. 7.0mm long, 7.5-11.5mm wide (9.5mm av.), lacking ornamentation. Infrabasals 5, horizontal proximally, upflared distally, visible in lateral view. Basals 5, 3.6mm long, 3.8mm wide, hexagonal, except CD basal heptagonal, gently convex transversely and longitudinally. Radials 5, 5.8mm long, 4.1mm wide, moderately convex transversely, gently convex longitudinally. Radial facet plenary. Single anal, widest distally, 4.2mm long, 3.8mm wide, slightly convex transversely and longitudinally, projecting slightly above radial summit. Axillary single primibrachs equidimensional, 5.8mm, strongly convex transversely, concave longitudinally, hourglass-shaped. Secundibrachs cuneate, short, moderately convex transversely, concave longitudinally, faintly staggered, probably with pinnule on shoulder of longer side. Arms 10, 2 per ray, branching isotomous. Stem homeomorphic, 58.0mm preserved, proximally transversely pentagonal for 14.5mm (5.0mm diameter), round distally (3.7mm diameter). Tegmen unknown.

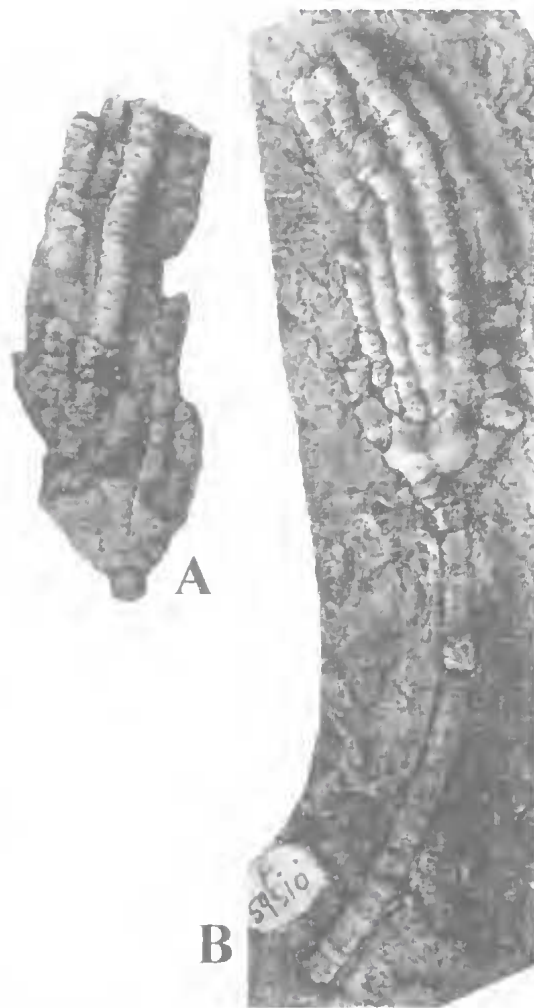


FIG. 19. *Holcoocrinus barrabaensis* sp. nov., A, B, posterior (AMSF59511) and anterior (AMSF59510) views, $\times 1$.

REMARKS. The holotype was embedded in mudstone. A cast (AMF59510) shows 58.0mm of stem. Part of the stem is now missing on the original.

Webster (1997) noted that *Holcoocrinus* has euneate brachials and suggested that it belongs to a clade of conservative inadunates retaining a conical cup. The infrabasals forming the truncated base of the cup with only the distal tips visible in lateral view and a single anal arc more advanced features within this conservative clade. The crown of *H. barrabaensis* is crushed normal to the BC-DE plane.

Holcoocrinus barrabaensis is distinguished within the genus by having a truncated medium conical

cup, brachials of intermediate length and lacking ornamentation. The cup of *H. wachsmuthi* (Meek & Worthen, 1861) is a much higher truncated cone. *H. spinobrachiatus* (Hall, 1861) has a broader medium bowl shape and all other species have low bowl-shaped cups. Brachials of *H. longicirrifera* (Wachsmuth & Springer in Miller, 1889) are very short and strongly cuneate, whereas those of *H. wachsmuthi* are longer, triangular and nearly biserial. Brachials of *H. nodobrachiatus* (Hall, 1861) and *H. spinobrachiatus* have short nodes or spines on the distal ends of the moderately cuneate brachials. Brachials of *H. barrabaensis* lack the spines, are longer than those of *H. longicirrifera* and shorter than those of *H. spinobrachiatus*. The axillary prinibrachs of *H. smythi* are much longer than those of *H. barrabaensis* which are longer than those of *H. longicirrifera*.

Poteriocrininid cup indet.

Crinoid allied to *Stemmatocrinus* Etheridge in Jack & Etheridge, 1892: 206, pl. 44, fig 7.

MATERIAL. QMF1196 probably from the late Tournaisian Malchi Formation, Rockhampton District. Collected by C.W. De Vis.

REMARKS. An indeterminate poteriocrininid cup 10.6mm wide is a slightly distorted internal mould and parts of 3 weathered radial facets. The basal circlet is subhorizontal and formed of 5 plates. Basals were horizontal proximally, upturned on the distal tips. One basal is wider than the other 4 and presumably had 1 or 2 anals above it. Cup walls were largely formed by the subvertical radials. Etheridge (in Jack & Etheridge, 1892) apparently thought the specimen lacked an anal plate when he considered it allied to *Stemmatocrinus* (= *Erisocrinus*). The cup could belong to any number of the poteriocrininids, depending on the number of anals and is considered indeterminate. Etheridge (in Jack & Etheridge, 1892) reported the specimen from the Gympie Beds, now considered to probably be from the Malchi Formation.

Poteriocrininid arms indet. #1 (Fig. 20A)

Arms of crinoid Etheridge in Jack & Etheridge, 1892: 210, pl. 7, fig. 8. Parfrey, 1996: 242.

MATERIAL. GSQF1588, external mould of a partial set of arms from the Tournaisian Rockhampton Group, Stony Creek, Stanwell. Collected by J. Smith.

DESCRIPTION. Partial set of 10 arms of at least 3 rays, 27.0mm long, 22.0mm wide, flaring distally.

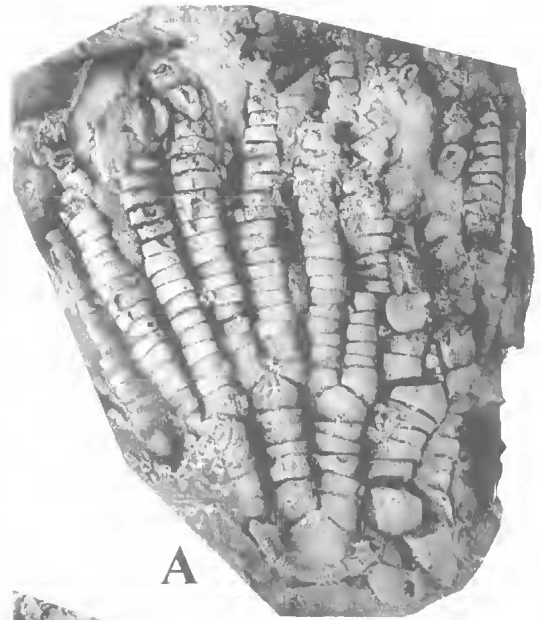


FIG 20. A, Poteriocrininid indet. arms #1, lateral view of arms GSQF1588, $\times 2.5$. B, Poteriocrininid indet. arms #2, lateral view of arms GSQF1587, $\times 2$.

Brachials smooth, no ornament, weakly cuneate, straight longitudinally, strongly convex

transversely, deep, U-shaped in transverse section, with slender pinnule on longer side. Ambulacral groove small, V-shaped. First secundibrach much longer than following secundibrachs, formed by fusing of 2 brachials. Isotomous branching on only primibrach preserved and axillary secundibrach 6

REMARKS. The brachial shape, branching pattern and longer 1st secundibrach are common to aphelecrinids to which this specimen may be related. The aphelecrinids are most common in Tournaian and early Viscon. strata of the United States and Scotland (Bassler & Moody, 1943; Webster, 1973, 1977, 1986, 1988, 1993).

The specimen is re-illustrated because the original does not show the distal part of the arms and is, in part, a reconstruction of part of the arms that are masked by matrix. No part of the cup is recognisable in the few fragmentary plates at the base of the arms.

Poteriocrinid arms indet. #2
(Fig. 20B)

Arms of crinoid Etheridge in Jack, & Etheridge, 1892: 210, pl. 7, fig. 7. Parfrey, 1996: 242.

MATERIAL. GSOJ1587, external mould of partial set of arms, from the Rockhampton Group, Rhynchonella Gully, Stanwell. Collected by J. Smith.

DESCRIPTION. Partial set of 8 arms, 34.6mm long, 30.8mm wide. Brachials weakly cuneate, straight longitudinally, strongly convex transversely, nearly circular in transverse section, bear transverse row of 3-5 coarse nodes projecting as exceedingly short spines. Ambulacral groove small, V-shaped. Pinnules slender, elongate.

REMARKS. Brachials of most poteriocrinids lack ornament. When present, the ornamentation commonly consists of fine granules or longitudinal or transverse ridges. Thus, the projecting spine-like nodes on the brachials of *Poteriocrinid* arms indet. #2 are very distinctive. *Chlidonocrinus echinatus*, a Late Carboniferous poteriocrinid from the United States (Strimple & Watkins, 1969), has similar spine-like node ornamentation but only 1 - 2 per brachial and not in an aligned transverse row. The brachials of *Neerkolocrinus typus* have irregular nodose ornament, not aligned in a transverse row and the brachials are much longer. The original illustration from the external mould does not show pinnules, which were not mentioned in the description (Etheridge in Jack & Etheridge, 1892). Without the cup, the specimen is left in open nomenclature.

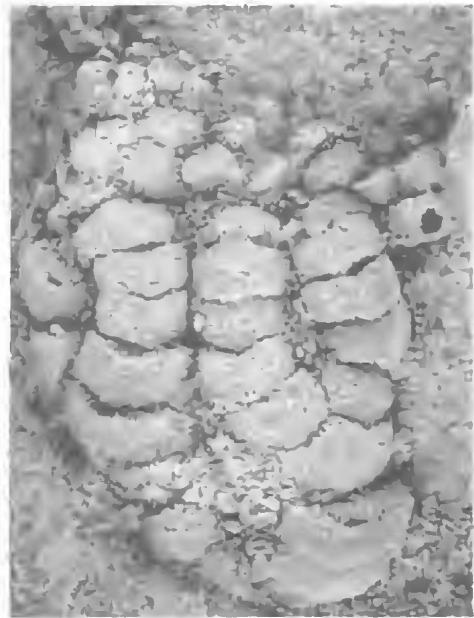


FIG. 21. *Taxocrinid* indet., lateral view of partial crown QMF38951, x4.3.

Subclass FLEXIBILIA Zittel, 1895
Order TAXOCRINIDA Springer, 1913
Superfamily TAXOCRINOIDEA
Angelin, 1878
Family TAXOCRINIDAE Angelin, 1878

Taxocrinid indet.
(Fig. 21)

MATERIAL. QMF38951 from QML508, late Tournaisian, Malchu Formation.

DESCRIPTION. Crown slender, elongate. Cup high truncated cone, with unornamented plates, with apical pits. Basals large, 7.5mm wide, strongly convex transversely with shallow longitudinal medial trough, distally upflared, distal tips incurved. Radials large, 14.0mm long, 14.2mm wide (incomplete), slightly convex longitudinally, strongly convex transversely. Radial facets angustary, with sharply convex outer rim, sloping inward, with short central transverse ridge 1/3 width of facet, with elongate ligament pit and large outer area aboral of ridge, inwardly with transverse pit adjacent to transverse ridge. Anal large, proximal 1/2 in line of radials. Brachials rectilinear, concave or straight longitudinally, strongly convex transversely, deep, not in contact laterally, with faint development of patelloid process, with deep wide V-shaped ambulacral groove. Brachial facets concave, with line

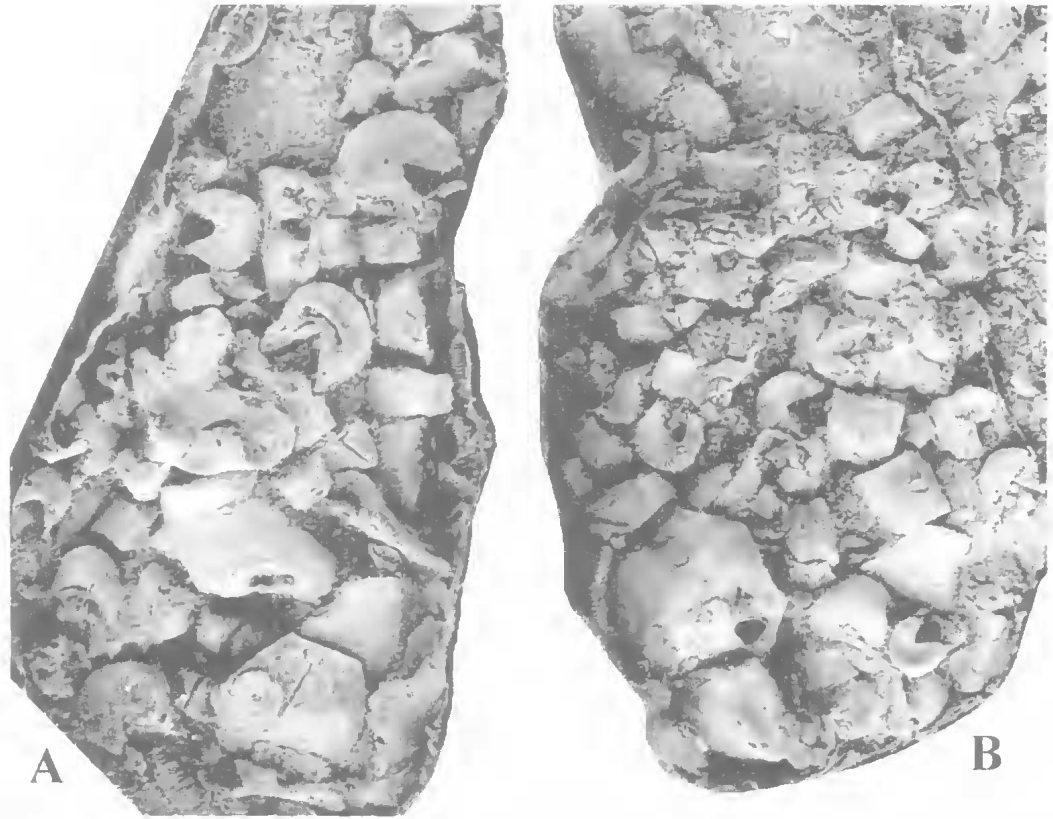


FIG. 22. A,B. Sagenocrinitoid indet., lateral views of opposite sides of disarticulated crown QMF38952a and b $\times 2.6$.

crenellae and culmina radiating from apex of ambulacral groove to aboral edge of facet covering an arc of 195° . Arms branching at least once and probably several times. Interprimibrachs unknown, but probably present. Anal tube plates large, with crenulate edges. Stem unknown.

REMARKS. QMF38951 is the external mould of both sides of a crushed, disarticulated crown. The specimen is assigned to the Taxocrinitidae because the radials are large, upflaring and have angustary radial facets, and the arms were not abutting. It is uncertain whether the cup includes more than 1 anal.

Articular facets of the brachials of *Forbesocrinus nobilis* de Koninck & Le Hon, 1854 (Springer, 1920, pl. 24, figs 13, 15, 18, 19, 23), *Syneroocrinus incurvus* (Trautschold, 1867) (Springer, 1920, pl. 42, figs 8i, 8k) and *Parichthyoocrinus nobilis* (Wachsniuth & Springer, 1880) (Springer, 1920, pl. 61, figs 5-8) have narrow crenularia only along the outer edges of the facet. The crenularium of this taxon

is quite different, radiating from the growth centre to the outer edges of the ossicle. The specimen probably represents a new genus, but is too incomplete to serve as a holotype.

Order SAGENOCRINIDA Springer, 1913
Superfamily SAGENOCRINITOIDEA
Roemer, 1854

Sagenocrinitoid indet.
(Fig. 22)

MATERIAL. QMF38952 from QML508, late Tournaisian, Malchi Formation.

DESCRIPTION. Partial set of arms, small. Brachials weakly convex longitudinally, moderately convex transversely; (smooth fine granulate surface reflects grains in matrix). Patelloid process small, weakly developed. Arms branch isotomously twice; 1st branching on 3rd brachial preserved. 2nd branching on 4th brachial of adjacent parts of first branching. Distal part of interbrachial, interprimibrachial, or anal series 2

large plates followed by numerous small irregular plates.

REMARKS. This fragmentary specimen may represent parts of 2 rays or part of 1 ray. It is assigned to the Sagenocrinoidea based on the interprimibrach or interbrachial series and branching pattern of the brachials.

ACKNOWLEDGEMENTS

Andrew Rozefelds helped collect the Rockhampton Group. Loan of specimens by the curators in charge of collections at the Queensland Geological Survey, Geological Survey of New South Wales, Australian Museum, Australian National University and British Museum is greatly appreciated. Paul Avern processed photographs. GDW extends his appreciation to Washington State University for granting professional leave and to the Director of the Queensland Museum for use of facilities and office space during prosecution of this project. The reviews of Bill Ausich and George Sevastopulo are kindly acknowledged.

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APPENDIX 1

Locality Register.

GSQ K-21 - Hill behind Pearson's Homestead. 0.8 mile N of Old Cannindah road intersection along Cannindah Road, Caswell Creek Group. Collected by R. McKellar.
 GSQ K-106 - Along side road off Stanwell-Dalma road. Rockhampton Sheet 1:250,000 yd grid:31760852; Ridgeland 1:100,000 Sheet GR 22024101: Late Carboniferous, Neerkol Formation. Collected by R. McKellar.
 GSQ L334 - Neerkol Formation, Late Carboniferous, W of Rockhampton.
 GSQ L3006 - Crow's Nest, NW of Mt Morgan, Mount Morgan 1:100,000 Sheet GR 284854; Gympie Beds of Jack & Etheridge (1892). Collected by J. Smith, 1888.

GSQ L3012 - Malchi Creek, probably Malchi Formation, W of Rockhampton, Queensland.
 QML508 - Mrs Harding's property, low hills 1km SE of homestead, above limestone hardground. KV252152; 8915 Ridgeland 1:100,000 Sheet, Rockhampton Group. Collected by P.A. Jell & A. Rozefelds.
 QML878 - 2000' W of Old Cannindah Homestead, Queensland. Oolitic limestone in Baywulla Formation, Early Carboniferous.
 QML1248 - North side of hill behind Old Cannindah homestead, Early Carboniferous Caswell Creek Group, Tournaisian or possibly Viscaan Tellebhang Limestone. 18.0 43.5 Monto 1:100,000 Sheet.

APPENDIX 2

List of described Carboniferous crinoid taxa from stratigraphic units of Queensland and New South Wales. Taxa preceded by an asterick (*) are not treated systematically herein.

Neerkol Formation, Westphalian, Qld.

Denarioacrocrinus neerkolensis gen. et sp. nov.
Denarioacrocrinus? ornatus sp. nov.
Neerkolocrinus typus gen. et sp. nov.
Kopriacrinus mckellari sp. nov.
Prinnocrinus namoiensis sp. nov.

Baywulla Formation, Viscaan, Qld.

Latocrinus sp.

Caswell Creek Group, Viscaan?, Qld.

Aacocrinus sp. 1
Sampsonocrinus cannindahensis sp. nov.
Dialutocrinus? sp.
Platyrcrinites nux? (Etheridge, 1892)

Rockhampton Group, Malchi Formation, late Tournaisian, Qld.

Actinocrinites sp. 1
Actinocrinites? sp. 3
Aacocrinus sp. 1
Manillacrinus browni (Dun & Benson, 1920)
Platyrcrinites sp. 2
Platyrcrinites sp. 3
Platyrcrinites sp. 4
 Camerate indet.
 **Poteroicrinites?* *smithii* (Etheridge, 1892)
 Poteroicrinimid cup indet.
 Poteroicrinimid arms indet. #1
 Poteroicrinimid arms indet. #2
 Taxocrinid indet.
 Sagenocrinitoid indet.

Neil's Creek Clastics, early or middle Tournaisian, Qld.

Actinocrinites sp. 2

Tellebhang Limestone, Tournaisian or Viscaan, Qld.

Aacocrinus acylus sp. nov.

Unknown horizon, possibly Namoi Formation, late Tournaisian, NSW.

Rhodocrinitid gen. nov.
Dichocrinus cf. *D. laudoni* Broadhead, 1981
 Scytalocrinid? indet.

Namoi Formation, late Tournaisian, NSW.

**Cribanocrinus biserialatus* Campbell & Bein, 1971
 **Glyphyrocrinus expansus* Lindley, 1988
Manillacrinus acanthus sp. nov.
Manillacrinus browni (Dun & Benson, 1920)
Platyrcrinites testudo Campbell & Bein, 1971
Platyrcrinites sp. 1
Holococrinus barrahaensis sp. nov.

Goonoo Goonoo Mudstone, late Tournaisian, NSW.

**Manillacrinus* sp. Campbell & Bein, 1971
Platyrcrinites testudo Campbell & Bein, 1971
 **Platyrcrinites* sp. 2 Campbell & Bein, 1971
Synbathocrinus ogivalis de Koninck, 1878
 **Cyathocrinites* sp. Campbell & Bein, 1971

Dangarfield Formation, late Tournaisian, NSW.

**Eumorphocrinus elongatus* Lindley, 1979
 **Glyphyrocrinus expansus* Lindley, 1988
 **Glyphyrocrinus minutus* Lindley, 1988

Flagstaff Formation?, Viscaan?, NSW.

Actinocrinitid indet.